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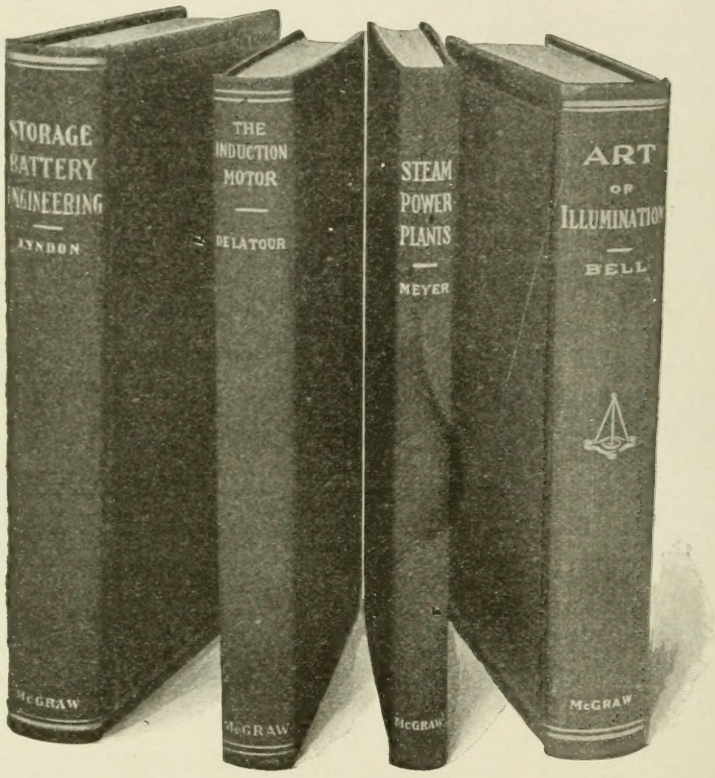

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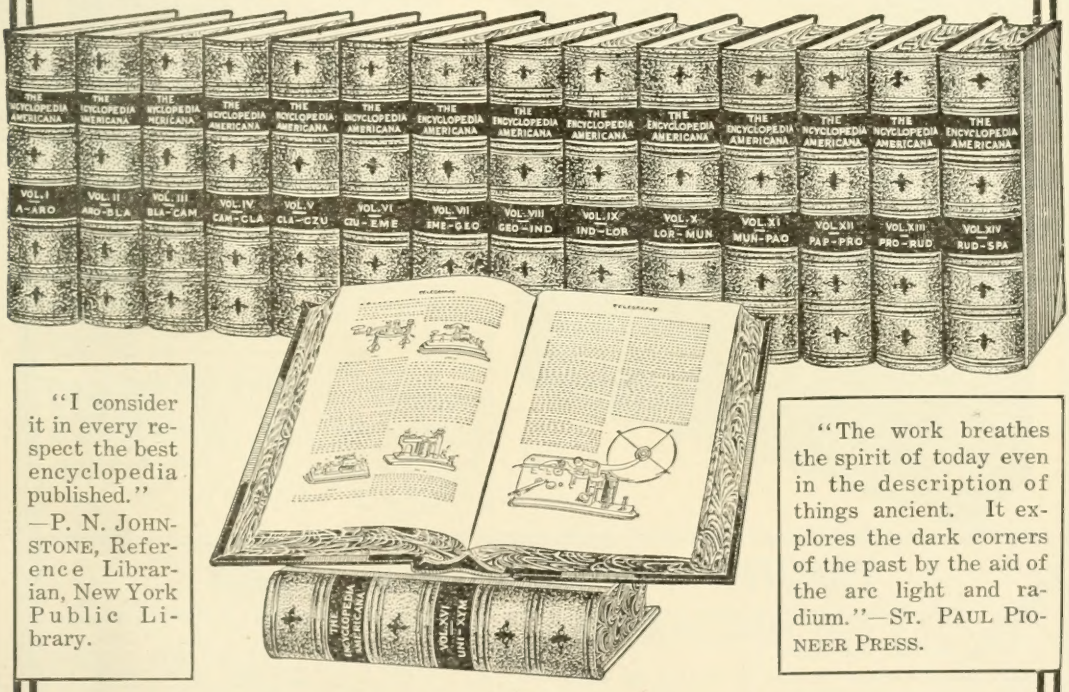

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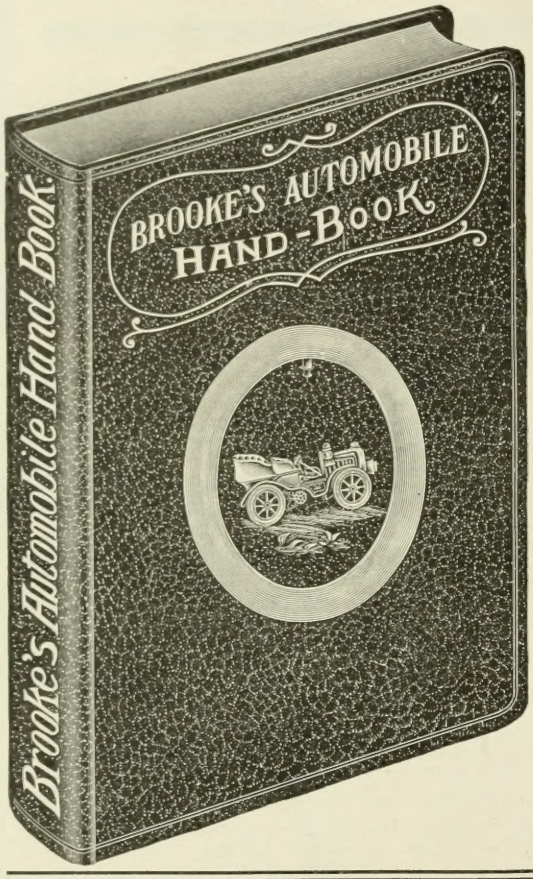

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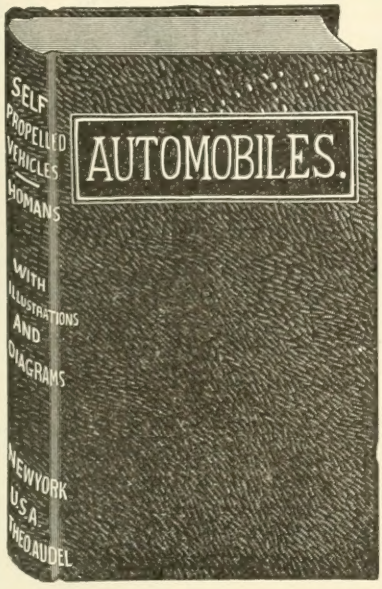

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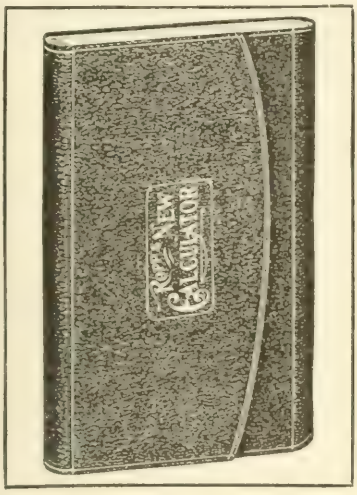

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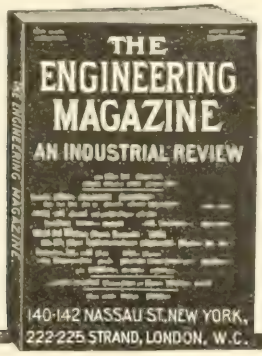

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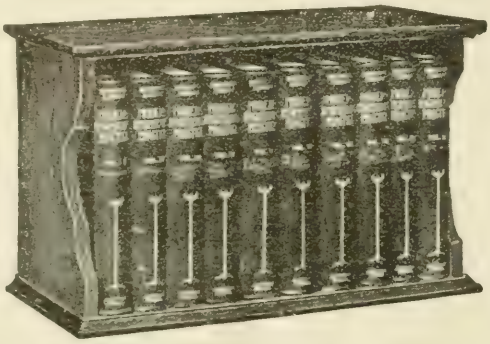

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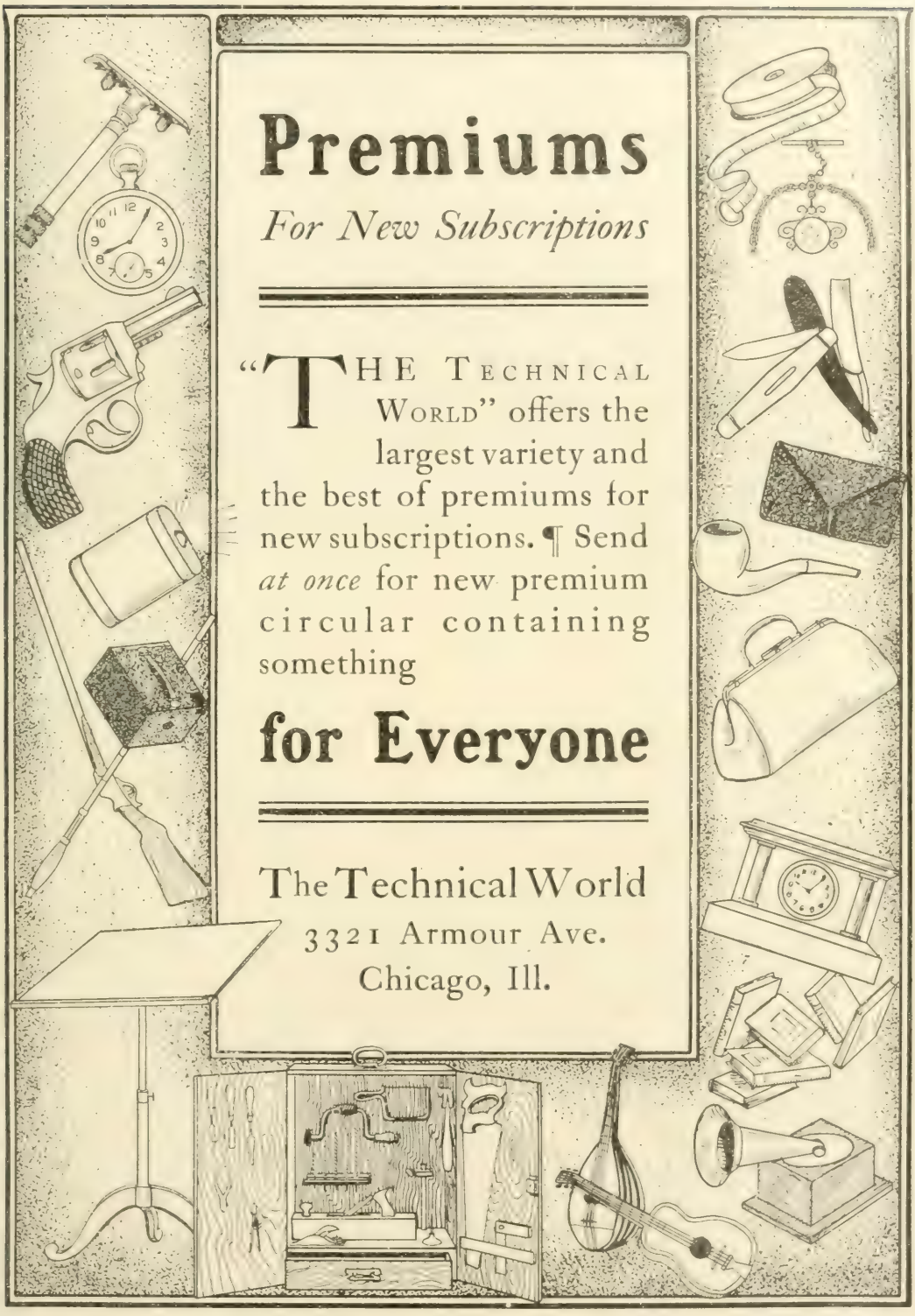

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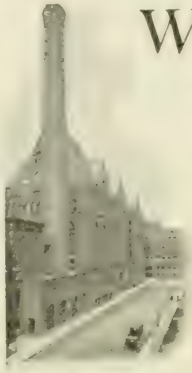

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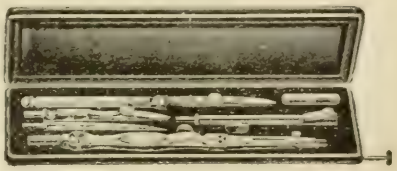

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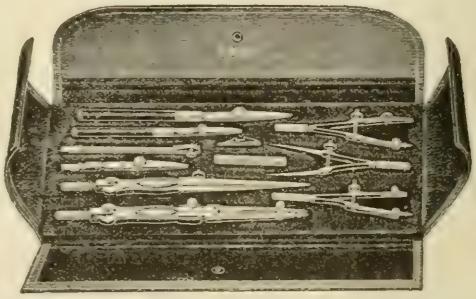

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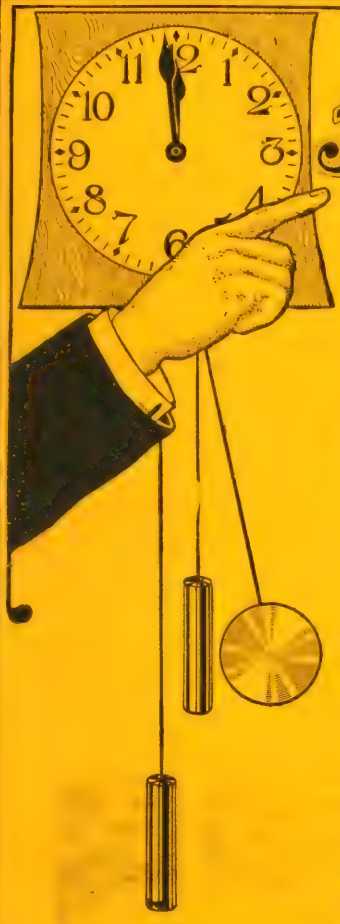

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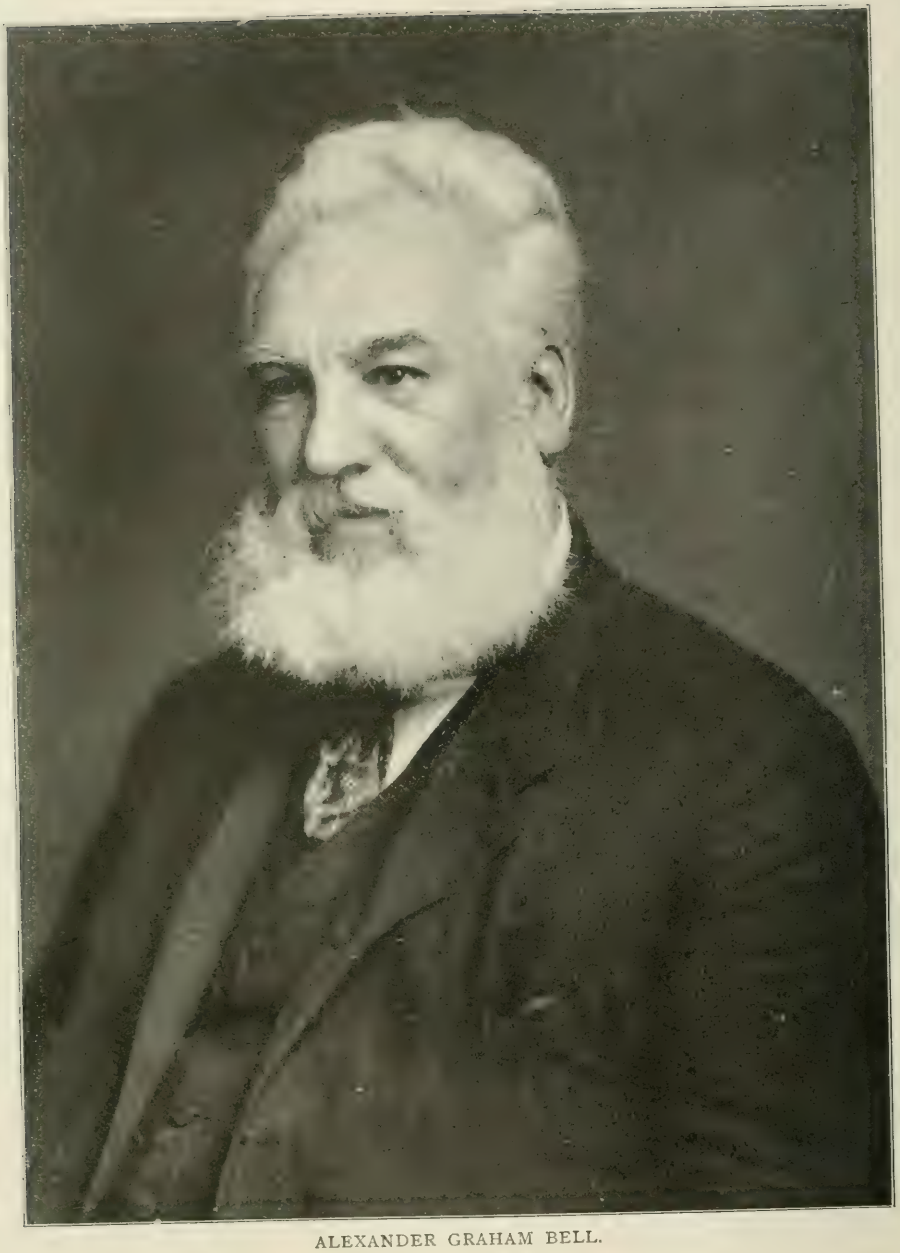


ALEXANDER GRAHAM BELL.

SCIENTIST AND INVENTOR.

Born in Edinburgh, Scotland, March 3, 1847.—In addition to his invention of the telephone—for which patent was granted February 14, 1876—Professor Bell invented the photophone (the earliest form of radiophone or wireless telephone), an induction balance, and a telephone probe for painless detection of bullets in the human body. His latest experiments have been along the line of scientific kite-flying, and his development of the tetrahedral kite has attracted much attention as bearing on the problem of aërial navigation.

The Technical World

Volume III MARCH, 1905 No. 1

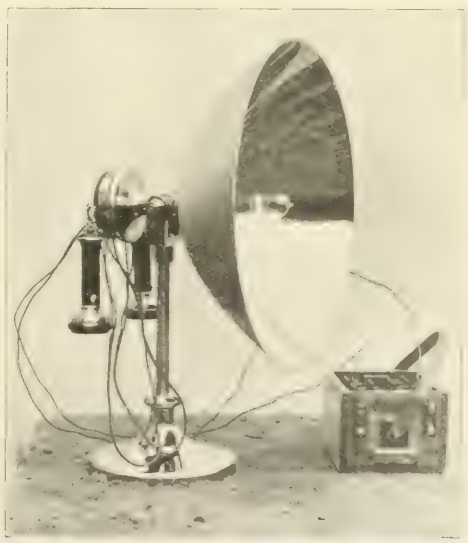
Wireless Telephony

By A. Frederick Collins

Author of "Wireless Telegraphy, Its History, Theory, and Practice"

THE transmission of intelligence by use of the electric current has reached, in its broadest sense, its final stage of development.

Intercommunication by means of an electrical disturbance set up for the purpose of propagating energy representing the alphabetic code or articulate speech, may be divided into four general classes — namely, Telegraphy with wires, Telephony with wires, Telegraphy without wires, and Telephony without wires. These principal classes, again, it is evident, may be subdivided into many branches; but there can be no further evolution in the art of sending and receiving messages by electrical methods, where instruments are interposed between those who are to be brought into mental relationship with one another.



ONE FORM OF WIRELESS TELEPHONE RECEIVER. Ruhmer System.

This is not to say that each of the forenamed systems approximates in its present state anything like perfection, for all are more or less crude in practice if not in theory; but any improvements that may be made in the future must differ from present attainments *in degree* and not *in kind*. Hence the *raison d'être* of the numerous arrangements for wire; and when wireless telegraphy made its spectacular debut a few years ago, there seemed to the casual observer no good and valid reason why speech propagation and reception without wires should not be considered as already at hand. To the investigator, however, it was soon revealed that history was repeating itself, and that wireless systems of telegraphy

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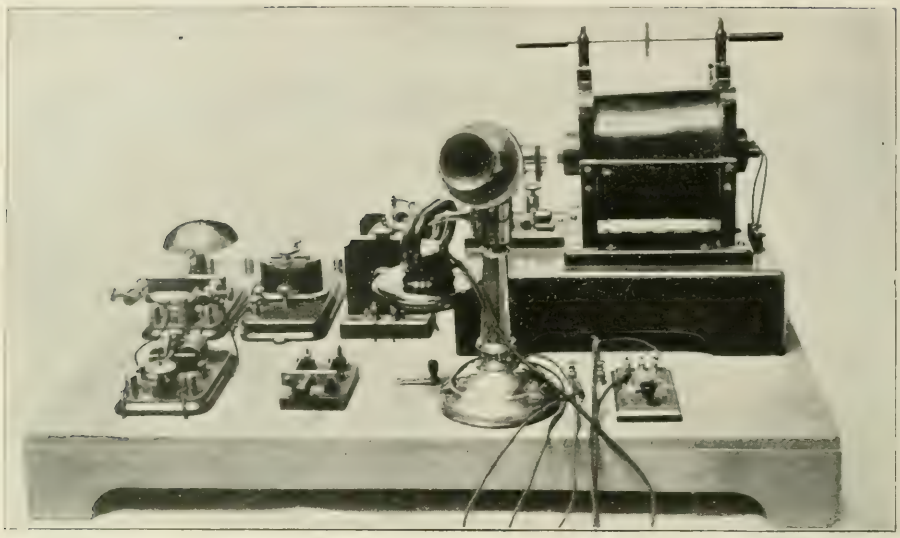


COLLINS WIRELESS TELEPHONE APPARATUS.

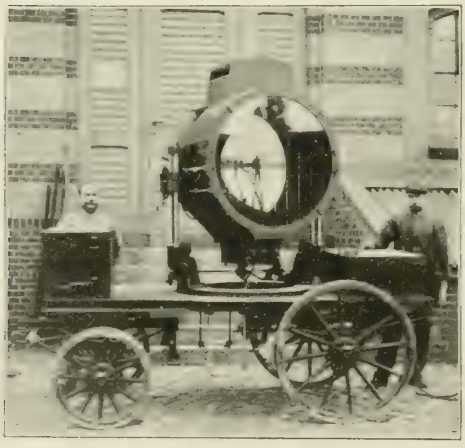
and telephony were as different in all their phases as were their predecessors which utilized the connecting wire. A brief analysis of these differences that mark so clearly the dividing line between the four great classes enumerated, will assist materially to an understanding of the fundamental principles of wireless telephony.

Evolution of Electrical Communication

When Morse took up the study of telegraphy, a working knowledge of the laws of electricity had not as yet been very accurately deduced. Induced and alternating currents had been explained by Henry and Faraday, but their usefulness remained to be indicated. It was well known, however, that a direct current traversing a wire was capable of energizing an electro-magnet; and from this fact Morse conceived the idea of the relay—the device that made telegraphy a commercial factor.

Although nearly half a century elapsed before Bell made his successful essay to produce a speaking telephone, electricity had not made so much progress as might have been expected. Reis had attempted to construct a telephone by utilizing a rapidly intermittent current, and these futile trials led Bell to believe that such a method was impracticable. Experimenting with steel reeds vibrating over magnets, he produced currents of varying strength—termed "undulatory currents" in virtue of their wave-like characteristics—and this formed the basic principle of the telephone.

In Marconi's wireless telegraphy, any kind of low-voltage current may be transformed into one of high potential and frequency; but in this system the oscillations of the transmitter emit their energy in the form of a train of waves with long intervals of time between them, and these oscillations, therefore, are not at all adapted to the transmission of voice undulations.



TENDER WITH REFLECTOR FOR OPTICAL OR WIRELESS TELEPHONE TRANSMISSION, RUHMER SYSTEM.

Mirror 90 centimeters (about 35½ inches) in diameter.

Methods of Speech Transmission

There are several methods whereby articulate speech can be transformed into electric current waves, which may, in turn, be propagated by the ether through air, earth, or water.

The first of these methods consists in the use of a battery and a telephone transmitter connected in series with terminals embedded in the earth or immersed in water. When the undulatory current flows through the circuit thus formed, the larger portion of its energy is dissipated, flowing out in curved stream lines, owing to the great cross-section of the earth, and extending to considerable distances. Now, if a complementary equipment consisting of a telephone receiver is likewise placed in contact with the earth by having its terminals similarly grounded, when the energy impinges upon these the current then flows through the receiver, and speech may be accurately reproduced.

A second method, ideal in its simplicity, is accomplished by electro-magnetic induction. Everyone knows that when a current flows through the primary of an induction coil, alternating currents are set up in the secondary coil by what is called "induction;" but not everyone knows that these coils may be widely separated before the limits of the inductive influence will be reached. If, for instance, a telephone transmitter and a source of electromotive force approximating 25 volts are included in the circuit of a coil of wire having, say, 25 turns and a diameter of 5 feet, and if a telephone receiver is included in a coil of wire having 60 turns and a diameter of 3 feet, words spoken into the transmitter can be distinctly heard in the receiver when the two instruments are separated a distance of 100 feet—providing, of course, that the coils have their planes parallel with each other. This is the "inductivity method;" and like the one previously described, it is operated by a low-voltage direct current.

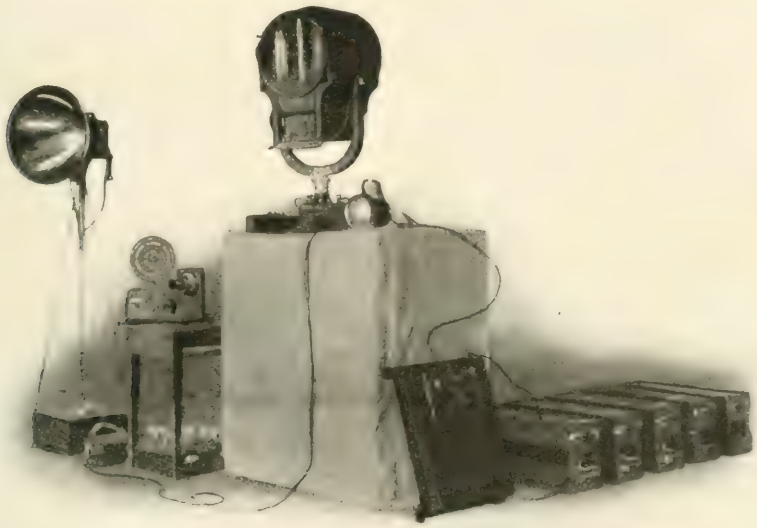


PHOTO-ELECTRIC TELEPHONE TRANSMITTER AND RECEIVER, RUHMER SYSTEM.

The receiving apparatus is shown on the left.—The essential elements of the Ruhmer System are the *selenium cell*, whose operation is clearly explained in this article, and the *speaking arc*. The latter, discovered by Professor Simon in 1898, is based on the fact that a continuous-current arc lamp will transmit sounds, feebly but distinctly, and will also vary in the intensity of its light, when an electric circuit traversed by feeble intermittent currents, or even the weak induction currents of a telephone circuit, is placed in parallel with, or superimposed upon, the arc-lamp circuit and in its immediate neighborhood.

The Bell Photophone or Radiophone

The invention of the telephone receiver led to many interesting experiments and to many curious discoveries. Prof. Alexander Graham Bell, in working with his new telephone, devised an apparatus for telephoning on a beam of light. This instrument, which he named the "photophone" or "radiophone," involved the use

Bell Radiophone Receiving Station as Installed at the World's Fair, St. Louis.

of selenium, a substance possessing the very remarkable property, under the action of light, of varying in electrical resistivity and its reciprocal, when fused in between two connecting wires of platinum or silver.

This apparatus is shown in the diagram, Fig. 1. The transmitter used by Bell was not electrical—for the transmitter, as we know it, had not been invented. Bell's transmitter comprised the mouthpiece *1*, a shell *2* supporting a thin metal diaphragm *3*, and, attached to the latter, a small concave mirror *4*. A plane mirror *5*, a convex condensing lens *6*, and a projecting lens *7*, all of which were suitably mounted on a frame, completed the apparatus for transforming the air vibrations produced by the voice into light variations of the projected beam.

The receiver was formed of a parabolic mirror *8* of large diameter, in the focus of which a selenium cell *9* was adjusted. The terminals of the conducting wires or electrodes of the cell led through insulated bushings in the reflector, to the back, where they were connected in series with a battery *10* and a telephone receiver *11*.

When the radiophone is in operation, the successive transformations take place in the following manner:—The light

Fig. 1. Diagram of Bell Radiophone.

from the sun is reflected by the plane mirror *5* to the condensing lens *6*, where its rays are focused on the concave mirror *4*. From the latter, the light is reflected to the lens *7*, whence it is propagated through the intervening space to the large parabolic reflector *8*, whereby its diffused waves are collected and concentrated to a pencil point on the selenium cell *9*. It is evident that any changes in the intensity of the light will alter the electrical resistance of the selenium cell, consequently causing variations in the current from the battery *10*, and finally affecting the telephone *11*.

When words are spoken into the transmitter, this is precisely what takes place, for the movements of the diaphragm of the transmitter cause the concave mirror to vibrate in unison with it, and every

Bell Radiophone Transmitting Station as Installed at the World's Fair, St. Louis.

change is thus indicated at the receiving end in virtue of these fluctuations.

The Ruhmer System

While the distance to which Bell was able to propagate the light variations representing the human voice, was not more than a few hundred feet, recent improve-

HERR RUHMER RECEIVING A PHOTO-ELECTRIC MESSAGE.

ments in the system by Herr Ernest Ruhmer have resulted in the transmission of speech a distance of several miles. This was made possible through the remarkable advance of electro-physics during the past few years. Prof. H. T. Simon ascertained that an ordinary arc-light could be made to reproduce articulate speech more clearly and distinctly

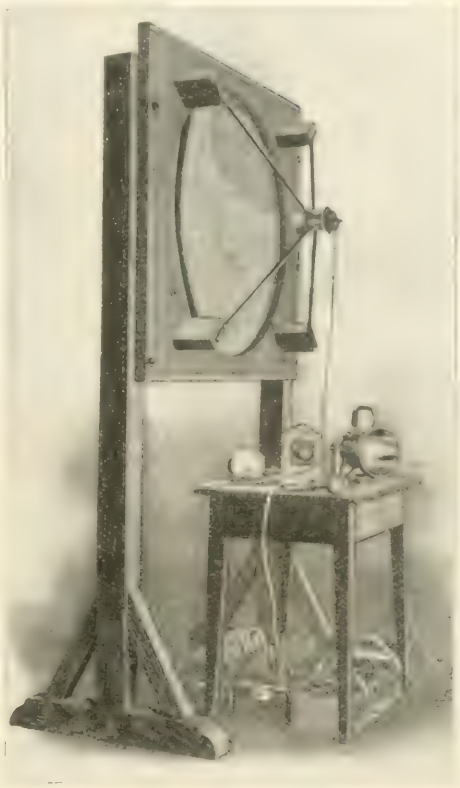


PHOTO-ELECTRIC TELEPHONE RECEIVER.
Ruhmer System.—Showing connections at rear.

than any phonograph, by superimposing a feeble alternating current upon a heavy direct current. The diagram, Fig. 2, illustrates one form of the method by which this may be accomplished.

An ordinary telephone transmitter *1* and battery *2* are connected in series with the primary of a small induction coil *3;* the secondary coil *4* leads through the

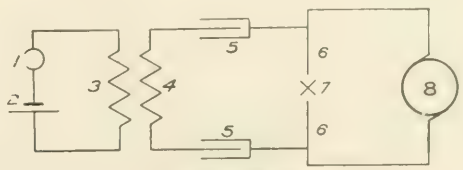


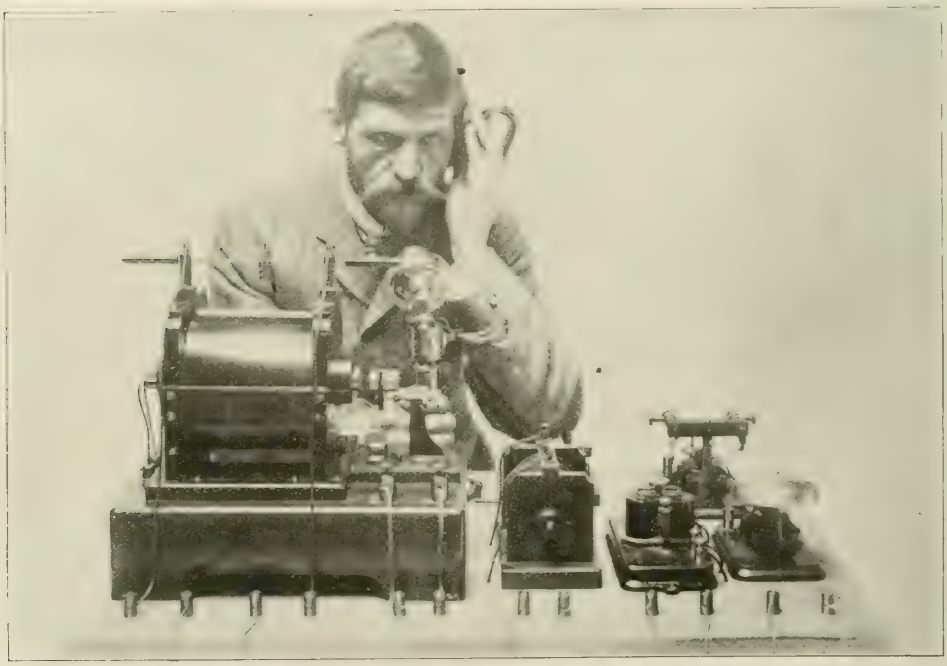
FIG. 2. SIMON SPEAKING ARC

condensers *5 5*, to the opposite carbons *6 6* forming the electrodes for the arc-light *7;* the latter is produced by a direct 50-volt current from a generator or—which is still better—a storage battery. When the speaking arc or "arcophone" is operated, the voice causes the air

BOAT ON WANSEE LAKE, EQUIPPED WITH RUHMER WIRELESS TELEPHONE APPARATUS.
Ruhmer's experiments on this lake effected perfect transmission of conversation between the shore and a boat anchored at a distance of nearly five miles.

waves to vary the resistance of the transmitter *1* in the usual manner; the current from the battery *2*, thus varied, energizes the primary coil *3*, setting up alternating currents in the secondary coil *4*. The condensers *5 5* produce no appreciable effect on the wave form of the current, which is superimposed upon the current from the generator flowing through the circuit formed of the carbons *6 6*, the arc-light *7*, and the generator *8*. The object of the condensers, however, is to prevent the direct current from backing up into the transmitter and burning it out. The superimposed current, however feeble, varies the resistance of the arc, and this produces a change in its temperature, which gives rise in turn to sound waves.

Another important function of the speaking arc is connected with the fact that there is also a variation of the intensity of the light which it emits. It is this by-product, as it were, of the speaking arc, that Ruhmer employs in his photo-electric telephone—a device which in all other respects is based upon



SENDING AND RECEIVING A PHOTO-ELECTRIC MESSAGE, COLLINS SYSTEM.

the original Bell photophone. In Ruhmer's system, the speaking arc is placed in the focus of a parabolic reflector, whence its rays are directed to the distant

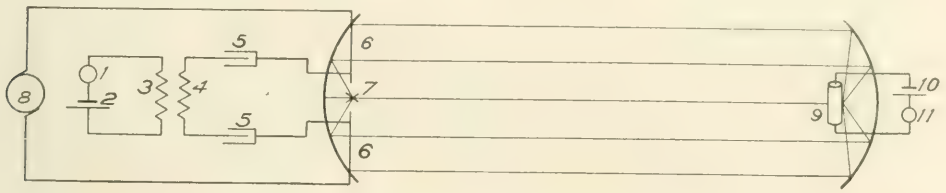


FIG. 3. DIAGRAM OF RUHMER PHOTO-ELECTRIC TELEPHONE.

receiver. When the two are in perfect alignment, a voice into the one will be distinctly audible in the other. The arrangement then takes the form shown diagrammatically in Fig. 3. With the description already given of the speaking arc and the selenium cell, the details of operation will be readily understood.

FIG. 4. HIGH-FREQUENCY OSCILLATION.

The Collins System

The writer, in endeavoring to bring about the advent of a commercial wireless telephone which would not be interfered with by fogs or other atmospheric conditions and which would not require either alignment or a direct visual line, investigated the several schemes of dis-

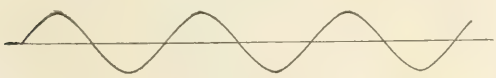


FIG. 5. SINE WAVE.

persion, inductivity, and electro-magnetic wave methods. The last-mentioned method is the most interesting, since it partakes of the nature of the wireless telegraph as well as of the wire telephone, yet it will do that which is not possible with either of the latter—namely, it will transmit articulate speech wirelessly.

In the beginning of this article, it was pointed out that electric waves, when emitted by a high-frequency and high-potential oscillation equalized through a spark-gap, were periodic, as indicated in the diagram, Fig. 4, the current strength decreasing in geometrical progression like the vibrations of a straight steel spring. In wireless telephony an undulatory oscillation is required, and this may be obtained by loading the radiating circuit with large inductances and capacities whose coefficients possess the properties of slowing down each oscillation until a more or less perfect sine wave results, as indicated in Fig. 5.

When this point is reached, the striking effect of the oscillatory discharge on the ether is greatly weakened, but at short distances the telephone will respond audibly without the usual coherer intervening. Some of the most recent work by the writer, however, has shown that a liquid detector made by immersing a platinum point and a platinum plate in an alkaline solution increases the volume of sound to an appreciable extent.

UPPER DECK OF FERRYBOAT "JOHN G. MCCULLOUGH," SHOWING MAST AND AERIAL WIRES USED IN COLLINS SYSTEM OF WIRELESS TELEPHONY.

The first series of tests with this type of apparatus was made at Rockland Lake, N. Y., a distance of a mile; while,

FERRYBOAT *RIDGEWOOD* EQUIPPED WITH COLLINS WIRELESS TELEPHONE APPARATUS.
Plying across Hudson River between New York and Jersey City.

under very favorable conditions, articulate speech has been transmitted and received over a distance of three miles and a-half. Successful tests have also been carried out between the ferryboats *John G. McCullough* and *Ridgewood* plying between New York and Jersey City.

The equipment of vessels with wireless telephone apparatus will tend to obviate the danger from collisions in harbors; while telephone communication between docks and vessels will facilitate transportation, thus saving time and money as well as insuring the safety of passengers and crews. The development of this latest phase of applied electrical science is another onward step in the march of human progress.

As We Measure

WE get back our mete as we measure;
We cannot do wrong and feel right,
Nor can we give pain and gain pleasure—
For justice avenges each slight.
The air for the wing of the sparrow,
The bush for the robin and wren,
But always the path that is narrow
And straight for the children of men.

—ALICE CARY.

A TYPICAL MINING TOWN OF THE WEST.
View of Burke, Idaho.—Hecla mine in foreground.

The Industrial Side of Copper

Mining and Smelting—The Marvelous Under-World of the Great Mining Districts—Handling and Refining the Output

By WILLIAM R. STEWART

Editorial Staff, *Cosmopolitan Magazine*

COPPER! What a jumbled suggestion of politics and law courts and stock exchanges the name has!—far more so than it conveys a picture of giant shafts and stopes, with under-surface villages equipped with all the devices of mining enginery, with regular town governments, fire departments, sanitation and drainage systems, telephones, electric conveyances, and a population running into the many thousands. It is because, for the time, the struggles and the rivalries of mine-owners, carried from private to public life, from the realm of litigation to the broader domain of state and federal politics, with all the financial intrigue which this involves, has assumed such spectacular proportions as to fill completely the public eye.

Yet the finest mining practice in the United States to-day is found in the copper mines of Lake Superior and Montana. The deepest shaft in the world leads into a copper mine. The richest ore body, acre for acre, is in a copper district.

To the man who knows copper only as a class of shares whose rise and fall in the market interests him or not, according to his investments, the spectacle of a copper-mining community would be a revelation. The city of Butte, Montana, furnishes the most striking illustration of the industrial importance of copper. From a struggling mining camp of a few years ago, it has jumped to a city of 45,000 population, over which the sulphur fumes hang heavy as a London fog by day, and the glare of molten rock

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MOUNTAINS OF COPPER ORE.
King Canyon, near Metcalf, Arizona.

from the smelters lights up weirdly the scene by night. Everywhere copper is in evidence. It is the sole talk of the people; it fills most of the columns of the newspapers. The latest invention in mining and smelting machinery, is all of science that the resident of Butte in general cares to know.

MACHINE DRILLING.
Veta Grande Mine, Sonora, Mexico.

But though Butte is the richest mining district in the world, producing about 250,000,000 tons of copper a year, it does not contain the greatest copper mine. The claim to the latter title belongs to the Michigan village of Calumet. There, in the deepest mine, more than two hundred miles of tunnels, and shafts more than a mile in depth, all electrically lighted, with electrically propelled cars and hoists, afford a picture that can be realized, but never wholly seen, of mining activity such as does not exist elsewhere on the globe.

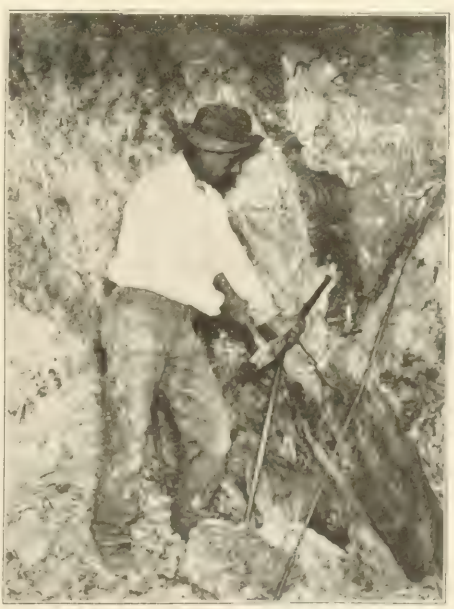
Where the Mines are Situated

About 80,000 wage-earners are now employed in the mining and smelting of copper in the United States, and the value of the product of the refineries last year was in round numbers $200,000,000. The principal copper districts are the Lake Superior, in Michigan; the Butte,

STOPING.
Veta Grande Mine, Sonora, Mexico.

in Montana; Shasta county, California; the Bingham district, in Utah; and the Ducktown, in Tennessee. Copper is found also in a number of places in Arizona, and in Wyoming, Washington, Oregon, Colorado, and New Mexico, though not in large deposits. About 600,000,000 tons is now the annual copper product of the United States.

To the layman there is a peculiar feature of copper mining in the fact that nothing so disgusts the mine-owner as to come across a mass of pure copper. He wants it adulterated or in small pieces. More than one mine has been almost ruined by the discovery of a great body



DRILLING COPPER ORE ONE MILE UNDERGROUND.
Wilson Mine, Metcalf, Arizona.

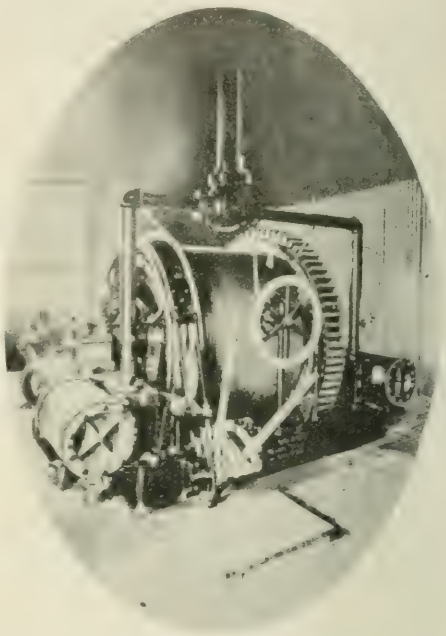
of pure copper. It could not be dug out; it would not yield to blasting. It had to be cut up with cold-chisels, and the expense was greater than the copper was worth.

Long before the white man came to America, an ancient race had mined pure copper by heaping and burning great piles of wood upon it, and then dousing the heated rock with cold water. Then they laboriously beat the chunks into smaller fragments, and carried them off to be hammered into tools and weapons. Copper that called for scientific reduction works had no value for the aboriginal miner. Now copper that does not need this treatment is valueless to his modern successor.

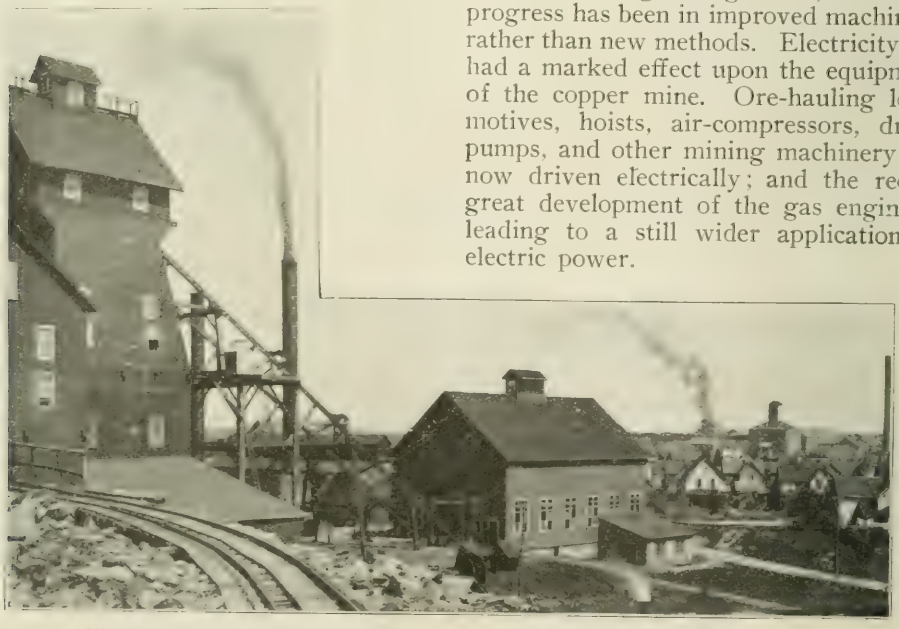
Modern Mechanical Appliances

To such an extent have mechanical appliances superseded hand labor in the treatment of copper, that now, at the principal copper-mining centers, the ore once shoveled into the tram-cars at the mines is never touched again by a shovel, but, passing variously from electric charging cars and slag cars, up electric elevators, and swung by electric cranes, through roasters, reverberatory furnaces, and Bessemer converters, finally emerges as pig copper at one end and waste slag at the other.

But that has to do with smelting. No less important have been the advances made in mining, though here, naturally, progress has been in improved machinery rather than new methods. Electricity has had a marked effect upon the equipment of the copper mine. Ore-hauling locomotives, hoists, air-compressors, drills, pumps, and other mining machinery are now driven electrically; and the recent great development of the gas engine is leading to a still wider application of electric power.



HOISTING ENGINE, OVER MINE SHAFT.

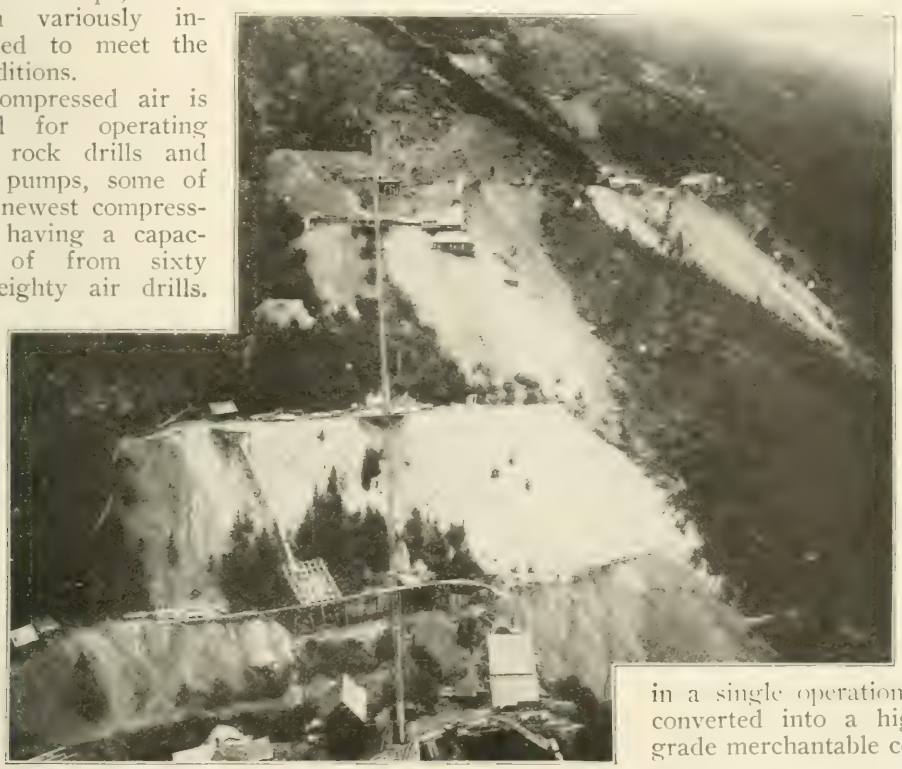


VIEW IN COPPER-MINING REGION OF UPPER PENINSULA OF MICHIGAN.

Tamarack Mine in foreground.—In square building with tower, on right of picture, is the deepest shaft in the world, the "Red Jacket," 4,900 feet deep, one of the Calumet & Hecla shafts.

The depths of the shafts of the copper mines in the Lake Superior district, and also in Montana—some of them over 5,000 feet—have called for the solution of many new problems in hoisting machinery. Double-cone drums with four cylinders, and enormous cylindrical drums thirty feet in diameter, all having a capacity of seven thousand or more feet of rope, have been variously installed to meet the conditions.

Compressed air is used for operating the rock drills and the pumps, some of the newest compressors having a capacity of from sixty to eighty air drills.



Bunker Hill Mine, Wardner, Idaho.
View showing different levels.

After blasting, the rock is loaded into cars holding two and a-half to ten tons, and in these hauled by electric traction to the various shafts, where it is hoisted to the surface either in skips that are self-dumping or in the cars themselves.

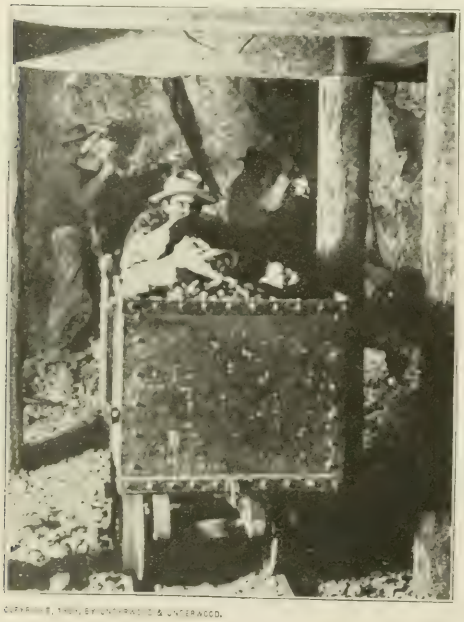
A rock-house is located at the head of each shaft, containing a crushing plant which breaks the rock into sizes of not larger than five or six inches in diameter. Railways then convey the broken rock to the stamp mills, which are equipped with large stamps operated by high-pressure steam. From 400 to 550 tons a day is the average capacity of each stamp, the screens through which the ore is crushed having openings of from 3-16 to ½ inch. There are hydraulic separators, jigs, tables, vanners, and regrinders in the mill; and when the ore passes through them all, it emerges as a "mineral," so called, containing anywhere from 40 to 85 per cent of metallic copper. This mineral, in the Lake Superior district, is sent to the smelting works, and in a single operation is converted into a high-grade merchantable copper.

The ore found in the Butte district of Montana is of such a nature—a mixture of the various sulphide copper minerals, iron pyrites, and silica—that it has to undergo a dressing by water to eliminate some of the silica before going to the smelter. One of the concentration and smelting plants built for this purpose cost more than $2,000,000 and has a capacity of 5,000 tons a day. Another point of difference between the Butte ores and those of the Lake Superior copper district, is that the former are so soft and friable that they do not lend themselves well to crushing by means of steam stamps and are in consequence treated by crushers and rolls.

LOADING ORE.
Veta Grande Mine, Greene Consolidated Copper Company, Sonora, Mexico.

Planning for the Future

The working of a copper mine is no haphazard affair. Apart from the precision which characterizes every operation of drilling, blasting, and hoisting, with all the intermediary steps involved, there is a systematic planning for the future, which must be as painstaking and as far-seeing as are the means whereby a commander of a great army provides for the feeding and equipment of his forces and for their safe retirement in case of defeat. New drifts are opened years ahead of their prospective actual operation; surveyors are at work measuring distances; gangs of workmen are busy timbering, and laying pipes and cables and rails—all in preparation for the time when the capacity of the mine will call for the working of additional veins.



IN THE MOUNTAIN'S HEART.
Running out copper ore, Wilson Mine, Metcalf, Arizona.

Timbering for Supports

The timbering of a great copper mine calls for all the practical skill of the experienced miner, and the expert knowledge of the geologist and surveyor as well. With hundreds of miles of tunnels, with shafts and inclines honeycombing

STOPING.
Elisa Mine, Sonora, Mexico.

the ground in every direction, and the lives of the miners dependent upon the stability of their rock-hewn workshops, the importance of substantial supports for the sides and roofs is easily realized. In some of the mines, the rock is so hard as to require but little timbering, but such cases are exceptional. The largest of the Lake Superior companies uses about 35,000,000 feet of timber a year, and mills capable of mortising sections of whole trees for underground supports have been built. The timber thus used is rendered fireproof, as far as possible, by coating with a solution of zinc chloride.

Methods of Smelting—The Bessemer and Other Processes

The smelting of copper ore—the process which changes the mineral as it comes from the stamp mills, or the converters, into the copper of commerce—has undergone marked changes in methods during recent years. For centuries, only two systems of furnace treatment were employed—the English method, in open,

reverberatory furnaces; and the German, in small shaft furnaces. The invention, by Bessemer, of a process for treating iron, based on the combustion of the carbon and silicon contained in pig iron till they are reduced to the percentage which should be contained in soft steel, not only revolutionized the steel trade but had an important effect on copper.

As applied to copper, the Bessemer process consists in blowing great draughts of compressed air through the matte, the oxygen in the air oxidizing the sulphur of the metallic sulphides, which escape as sulphur dioxide. During this transformation a large amount of heat is liberated, enough to keep the matte molten for some time. To oxidize forty tons of 50 per cent matte a day, 4,000

A Water-Jacketed Furnace.

cubic feet of air a minute must be blown through the tuyères of a converter.

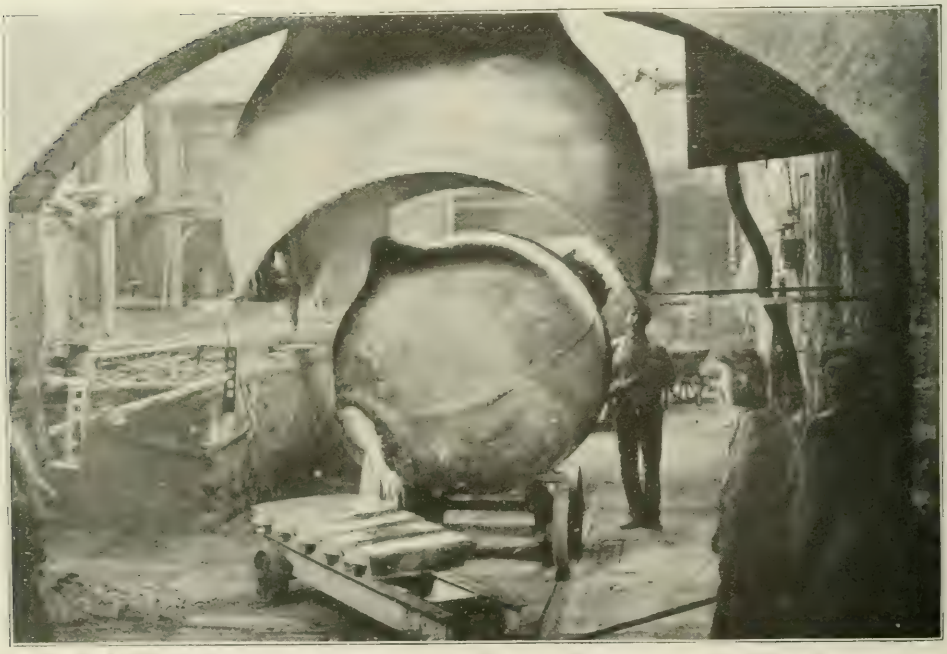
There is a difference in the application of the Bessemer method to iron and to copper. In the former case, where the material is not a single metal but an alloy of iron and several metals, all of which evolve great heat during oxidation, no difficulty was experienced in keeping the mass in a fluid state in the converters.

Veta Grande Shaft, No. 2, Sonora, Mexico.

Copper, however, when treated in the ordinary steel converter, chilled and clogged the tuyères. In producing steel, the blast of air is forced through the bottom of the converter from below, and passes through the molten cast iron in vertical tuyères. In smelting copper, on the other hand, in order to avoid the clog-

Pouring Matte into Converter.

THE FIRST BLOW.
During this stage, a partial removal of iron and sulphur occurs.



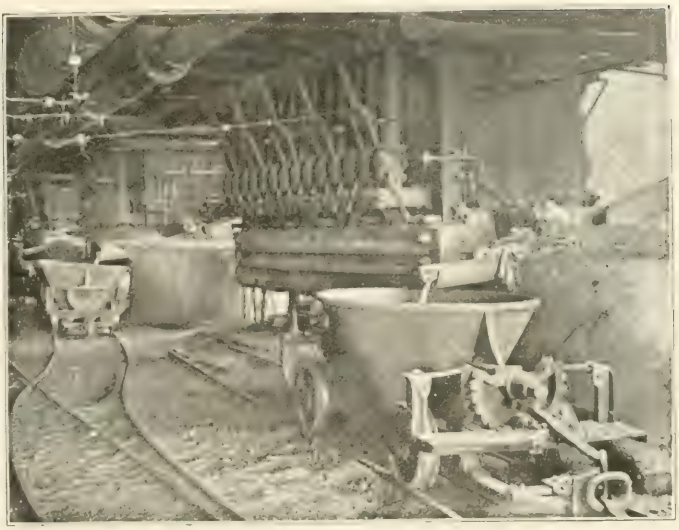
CASTING THE FINAL PRODUCT INTO MOULDS.

ging, the tuyères are elevated and horizontally set, so that the copper when formed settles below their level, and the tuyères can easily be reached and cleared of any copper which may adhere to them.

A distinct advance in the application of the Bessemer process to copper smelting has been made by the invention of a new type of converter which is rapidly coming into use. This converter differs from the old form in being spherical, and in possessing a "pocket" located near the mouth, into which the precious metals (gold and silver) found in the copper ore drop and are separated. The principle of the invention is the well-known one, that, in forcing air through molten copper matte, the precious metals lose their sulphur first, and sink to the bottom as alloys, at the same time taking with them such impurities in the matte as lead, zinc, nickel, cobalt, arsenic, and antimony. All the gold which may exist in the matte is found in this bottom copper, and it is separated by electrolysis after the whole has been cast into anode plates.

The saving of labor and the greater speed in operation, through the Bessemer process, is marvelous. Minutes will now suffice where hours before were required; and square feet of space will be sufficient where formerly acres were covered by furnaces and roasting stalls.

The Bessemer process, of course, is applicable only to copper which contains a certain amount of sulphur; and in the Lake Superior district, where unalloyed copper is found, other methods are employed. There the mineral, as it comes from the stamp mill, is charged into reverberatory furnaces and melted down, and the slag is skimmed off. It is rabbled and poled, and is then fit to be cast into ingots or wire bars.



Smelting Furnaces, with Slag Cars.

There are more than fifty copper smelting and refining establishments in the United States, and their aggregate productive capacity is $65,000,000 worth of copper. As shown by the latest figures obtainable, they give employment to 15,000 wage-earners.

Bullion Floor of a Copper Smelting Plant.

UNITED STATES NAVAL OBSERVATORY, WASHINGTON, D. C.

Located at Georgetown Heights overlooking the national capital.—Appropriations for purchase of present site made by Congress in 1884, and building completed in 1893.

Distribution of Time Signals

Many-Sided Activities of the U. S. Naval Observatory at Washington, D. C.—The Determination of Time, and Other Important Astronomical Work

By WALDON FAWCETT

SEVERAL notable achievements and a progressive advance in aims and administration, have of late brought into special prominence the work of the United States Naval Observatory at Washington, D. C. Though the youngest among the great astronomical institutions of the New World, this observatory unquestionably ranks with that at Greenwich, near London, and that at Pulkowa near St. Petersburg. It is but little known, however, to the general public in the United States. Though its unusual attainments have won the enthusiastic admiration of scientific circles throughout the world, it is less heard of than are many private institutions in this country. This is doubtless due in great measure to the fact that the object of the governmental institution is not the further discovery of the unknown, but the development and application of the known—the one purpose which, of the two, is likely to be by far the more beneficial to mankind in general.

Growth of the Institution

The United States Naval Observatory was established in 1842, prior to which time this Government was almost wholly dependent upon Greenwich, Pulkowa, and Paris, and on college observatories on this side of the Atlantic. As early as 1833, however, there appeared a forerunner of the present magnificent institution, in the form of an unpretentious frame structure sixteen feet square, erected under the shadow of the National Capitol at the expense of Lieutenant Wilkes, an American naval officer. This small building was equipped with a 5-foot Troughton transit which had been manufactured in England early in the century for the use of the United States Coast Survey, but which was not needed for that service when Congress refused to authorize the establishment of a national observatory.

The object of Lieutenant Wilkes in establishing his naval observatory in embryo, was solely to provide facilities for obtaining the clock errors needed for the determination of true time and the rating of naval chronometers then under his charge. However, the testing of all chronometers and other naval instruments used by United States vessels was found to be so wise and beneficial that the Secretary of the Navy speedily took it upon himself to give the little observatory official recognition under the title "A Depot for Charts and Instruments," and an officer was regularly detailed to look after the work of the institution.

In 1838, there were made upon the young institution unexpected demands which in their fulfilment so demonstrated its usefulness that its future was in a measure assured. An exploring expedition in the results of whose researches the United States was very deeply interested, sailed for the South Seas; and, in perfecting the plans for its work, the discovery was made that it was well-nigh essential to the accurate determination of the longitude of the places visited by the expedition, that corresponding observations should be made at home, in order to afford comparisons with the data obtained by the explorers. The Secretary of the Navy turned this task over to Lieutenant Gilliss, who had succeeded Lieutenant Wilkes, the founder of the Observatory; and, under stress of the new exactions, an achromatic telescope was added to the equipment of the miniature institution. For four

THE BIG TELESCOPE AT THE NAVAL OBSERVATORY.

years, though handicapped by inadequate equipment, Lieutenant Gilliss discharged faithfully and accurately the duties thus suddenly thrust upon him, and won by his success the applause of many of the foremost astronomers of Europe.

The most clearly defined development of this interesting institution dated from the time when, as a result of the object-lesson afforded by the work of Gilliss, an appropriation of $25,000 was secured. Even after this, however, the establishment continued to be known officially as the Depot of Charts and Instruments, partisan reasons preventing Congress from allowing it to be designated as an "observatory."

The first site chosen for the permanent home of the institution was selected by President Tyler. It consisted of a tract of nineteen acres which had originally been set aside for a national university —one of the pet schemes of George Washington. This location was soon found to be unsatisfactory, owing to the fact that its proximity to the heart of the city involved almost constant vibration; but it was not until 1884 that Congress could be induced to make appropriation for the purchase of the present admirable site on Georgetown Heights, overlooking the national capital.

Once the new institution was formally established, the Obervatories at Berlin, Paris, Greenwich, and Vienna generously made a donation of some two hundred rare volumes of the highest standard, as a nucleus for an astronomical library. With this modest start, the library of the Naval Observatory has grown until the collection now numbers more than 22,000 volumes and pamphlets, and ranks second only to that at Pulkowa. In 1874 the institution installed the largest refracting telescope then in existence—the famous 26-inch equatorial. This telescope was set in place just in time to observe the transit of Venus, which occurs but about once in a lifetime and which affords a valuable method of determining the sun's parallax—the base-line measurement for determining celestial distances.

The present home of the Naval Observatory was completed in 1893. As has been explained, the site has a con-

siderable elevation over much of the surrounding country; and the original site has been so extended by supplementary purchases of land, that the proper and essential isolation of the institution would seem to be insured for all time.

Equipment

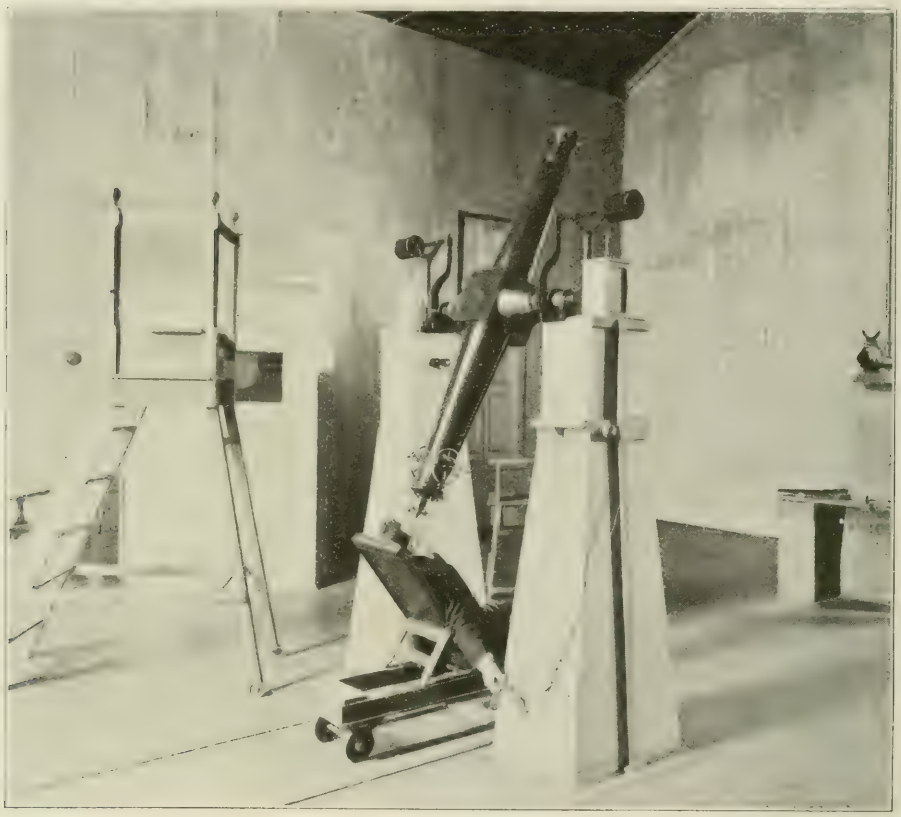
The equipment of the Naval Observatory is all that could be desired. The dome that houses the great equatorial is a particularly wonderful piece of mechanism. Although exceeding six tons in weight, it is so perfectly balanced that its huge bulk can be swung round, raised, or lowered by one man without excessive effort. The dome rolls around on a circular wall so that an opening for the telescope can be presented toward any part of the heavens. The entire floor of the apartment containing the large telescope, rises and falls by means of hydraulic power, after the fashion of an elevator, thus giving easy access to the instrument in all positions.

ANOTHER VIEW OF THE 26-INCH EQUATORIAL AT THE NAVAL OBSERVATORY.
This refracting telescope is surpassed in size only by the 36-inch Lick and 40-inch Yerkes refractors.

In additon to the 26-inch equatorial, the equipment of the Naval Observatory includes a 9-inch transit, a 6-inch transit circle, a 12-inch equatorial, a prime vertical transit instrument, a 6-inch azimuth, and a 40-foot photo-heliograph. The latter is used in the daily photographing of the sun.

A feature of the equipment which is worthy of special mention, is the Clock Room, or, rather, the vault connected therewith, which was designed and constructed with a view to removing from all disturbing influences the delicately adjusted time-pieces upon which dependence must be placed in much of the work of the Observatory. The clock vault is

8 feet square and 7 feet high, and its whole construction has been with a view to keeping the temperature very nearly constant throughout the year. In the vault is a frame structure of the dimensions above given; and, inclosing this, is a 9-inch brick wall. Between the frame and brick construction there is an air space of 12 inches which contains hot-water pipes for heating. The entire structure is closely roofed with boards, inclosing a 6-inch layer of asbestos wool. The vault contains three brick piers for clocks, and one smaller pier for mounting a pendulum apparatus designed for testing the minor irregularities of clock rates. The vault is provided with triple doors and with means for slow ventilation; and, inasmuch as it is located on the summit of a hill, the drainage conditions are such that the basement containing the vault is remarkably dry, so that there has thus far been little damage from rust.



TRANSIT INSTRUMENT.
Used in determining time by observing passage of star across meridian.

Time Signals Flashed

One of the most important functions of the Naval Observatory is found in the daily distribution of the correct time to every portion of the United States. This is effected by means of telegraphic signals, which are sent out from Washington at noon daily, except Sundays. The original object of this time service was to furnish mariners in the seaboard cities with the means of regulating their chronometers; but, like many another governmental activity, its scope has gradually broadened until it has become of general usefulness. The electrical impulse which goes forth from the Observatory at noon each day, now sets or regulates automatically more than 70,000 clocks located in all parts of the United

States, and also serves, in each of the larger cities of the country, to release a time-ball located on some lofty building of central location. The dropping of the time-ball—accompanied, at some points, with the simultaneous firing of a cannon—is the signal for the regulation by hand of hundreds of other clocks and watches in the vicinity.

The large telescope — which, by the way, cost $46,000, and has few rivals save the 36-inch Lick telescope in California and the 40-inch Yerkes telescope of the University of Chicago—is not used in the determination of time. In this work, only the transit instrument is used. By means of this latter piece of apparatus, an observer watches the movements of the stars on each clear night, and, by their aid, corrects the large Frodsham clock which stands in the Signal Room of the Observatory.

In this phase of the observations, spiders' webs play an important part, being used to form cross-lines extending at right angles across the field of view so as to divide it into mathematical spaces. The web of the spider, it may be explained, is not only exceedingly fine, but of great strength considering its delicacy of texture. These nets of fragile strands also possess remarkable stability in another respect—namely, that they are not affected by moisture, and do not expand or contract as a result of changes in temperature. Formerly the directors of the Naval Observatory sent to China for all the spiders' webs required, it being supposed that the large spiders of the Orient produced the most desirable webs for scientific purposes; but of late years it has been discovered that the webs of spiders found in certain portions of the United States are equally suitable.

How Time is Determined

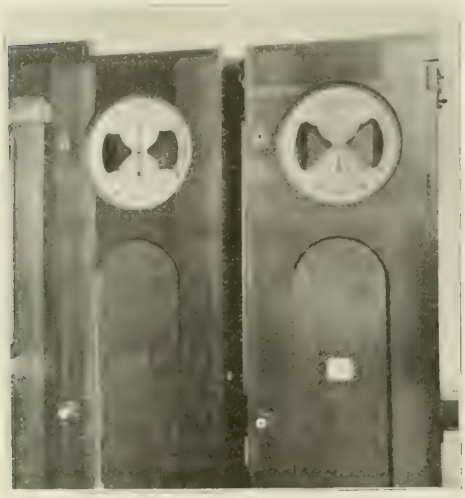
The time determination at the Naval Observatory is manifestly one of its most important activities, since the sun is irregular and cannot safely be depended upon as a measurer of time. The actual elapsed time required for one revolution of the earth on its axis can be accurately determined only by measuring the interval between two passages of a given star across a designated meridian of the earth—intervals which do not vary from century to century. This, then, becomes the basis of the work of time determination. It is, however, a foundation not secured without considerable effort, for the number of revolutions which the earth actually makes on its axis is one greater than the number of so-called solar days in the year as prescribed by the calendar in common use. Accordingly, the day, hour, minute, and second as determined by the stars are shorter than those of the sun as told off by our clocks; and consequently the time of the "star clock"—which is corrected directly

Sending Noonday Time Signal.

from the stars by means of the transit —must needs be translated into solar time ere it can be of use to Uncle Sam's citizens in the readjustment of their timepieces.

Time correction by the stars is in itself an interesting process. As an aid, the observer has the *Nautical Almanac,* a practically infallible time-table of the stars. This great work is compiled year by year as the combined result of that careful timing of the days of the stars which is ever in progress at all the prin-

cipal observatories scattered over the globe. By consulting the Almanac, an observer learns at exactly what hour, minute, and second the star under observation should cross the meridian. Taking his place under the telescope, he



Automatic Signal Clocks.

awaits the scheduled passage of the star. Precisely as the latter crosses the imaginary line, the observer presses a telegraph key, and the exact time of passage is accurately registered by the chronograph. This instrument, in popular parlance, might be compared to a clock with a revolving cylinder of paper for a dial. Moving over this paper, instead of a second hand, is a fountain pen which answers the electrical impulse by making a mark on the paper cylinder at the exact instant that the circuit is closed. The "star clock" whose inaccuracies are thus determined at such cost of time and labor, is never literally set right. Allowance is merely made in subsequent calculations for any errors which may have been discovered, these errors amounting only to an infinitesimal part of a second in many days.

The translation and transmission of the correct time from the star clock to the clocks which are directly responsible for the sending of the time signal, is accomplished by mechanical methods very similar to those already referred to. The paper-covered cylinder of the recording device is made to revolve at a fixed speed, passing under a stationary pen loaded with red ink. Behind the dial in each clock, marking the seconds, is a cogged wheel each cog of which in turn touches a brass spring, thereby closing the circuit of a battery, and, by a mechanical arrangement, causing the pen above mentioned to make a horizontal mark on the paper enveloping the cylinder. This affords a permanent record of each second. The star clock is also in circuit with the recording pen. A cup of mercury resting in the clock is connected with one pole of the battery. The pendulum is connected with the other. As the latter swings, it touches the mercury in the cup, closing the circuit and sending an electric impulse which causes the pen to do its work. It is comparatively easy to set one of the ordinary clocks within a second of the star clock; but an adjustment of a fraction of a second requires measurements of great nicety. Corrections such as above described are made a comparatively short time before noon, so that there will be little opportunity for the clocks to gain or lose before the time at which the all-important signal is dispatched.

The clocks which contain the mechanism for sending the time signal, cost upwards of $800 each. As a precaution against accident, two of these clocks are provided; but only one is used in sending the signal. At three and a-quarter minutes before noon, the signal clock is switched into the telegraph circuit which covers the entire country; and from that moment until the sending of the signal, all business is suspended throughout the 350,000 miles of telegraph lines over which it is to be flashed. Warnings of the approach of the time signal precede by short intervals the actual announcement of the noon hour. These warnings are in part sent automatically. The signal clock is fitted with a toothed wheel which is located directly behind the wheel that marks the seconds, and which is divided into sixty spaces corresponding to the seconds in a minute. However, the tooth representing the twenty-ninth second is missing; and so, likewise, are those representing the fifty-fifth to the fifty-ninth second, respectively. As the wheel revolves, the teeth come in contact

with a spring which is in connection with the electric current, closing the circuit and causing the sounder to respond. The absence of the twenty-ninth tooth causes the twenty-ninth signal to be omitted, and indicates the approach of a half-minute; and then the skipping of the five beats announces the approaching conclusion of the minute. All this takes place in the next to the last minute of the final hour. There is a third warning interval of twenty seconds before the supreme signal; but this is produced not automatically but by the telegraph operator at the Observatory, and occurs when he moves the switch key which throws out of the circuit the wheel marking the seconds, and throws into the circuit the wheel marking the minutes.

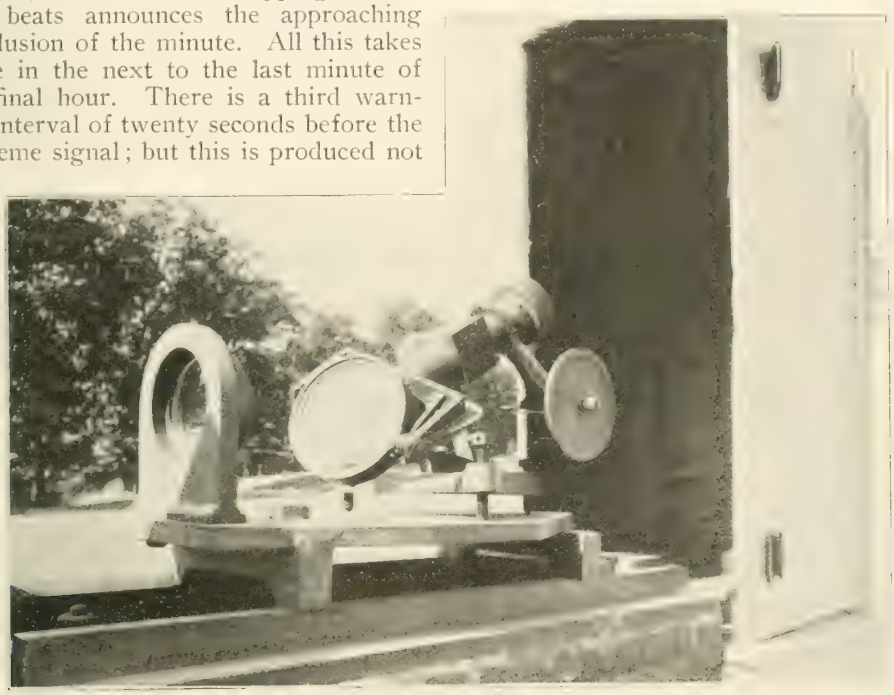


PHOTO-HELIOGRAPH
Instrument for photographing the sun.

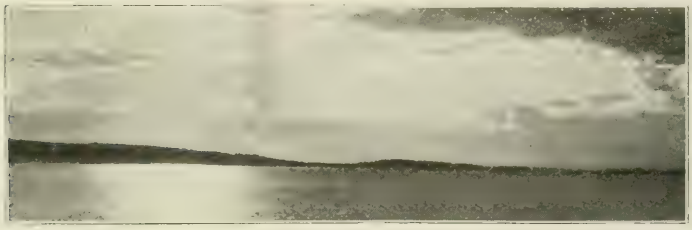
In the final one-hundredth of the last second of the fifty-ninth minute of the last hour at Washington, the tooth of the minute wheel touches the spring which closes the circuit. Simultaneously, the announcement is flashed to every part of the country, the flow of the current serving of itself to release the time-balls which have shortly before been hoisted to the tops of the staffs in various cities. How rapidly the signal travels may be appreciated from the fact that it is flashed from Washington to San Francisco in one-fifth of a second. Since the time signal is sent out from Washington at noon, or at 12 o'clock standard Eastern time, and there are four different standard times in the United States, determined by geographical locations, it will be appreciated that the signal from Washington will reach the Central, Mountain, and Pacific Time Belts at 11 o'clock, 10 o'clock, and 9 o'clock A. M., respectively. On the last night of the year, the time signal—which in this instance marks the advent of the New Year—is sent entirely around the world, traveling over 1,180,000 miles of wire and cables, and making the circuit of the globe in ten seconds.

Yet another phase of the activities of the Naval Observatory is found in the regulation of all the chronometers of the Navy. How important is this duty, may be appreciated from the fact that a second of error in a ship's chronometer at the equator means a variation of more than sixteen miles east or west of the mariner's calculation of his position.

Photographing the Sun

In the photographing of the sun to which reference has previously been

made, extreme care and skill are required, it being necessary to use extremely delicate plates and to develop them by special methods. Considerably more than one hundred photographs of the sun are made each year. The camera with which the sun is photographed has a triangular box 35 feet in length. The lens is five inches in diameter, and has a focal length of forty feet. The shutter travels across a six-inch opening. The negatives, which are taken on every clear day in the year, are carefully filed for reference, and are measured with the greatest accuracy in order to show the changing positions of the sun spots, their sizes, shapes, etc.



A Prayer

THE day returns, and brings us the petty rounds of irritating concerns and duties. ¶ Help us to play the Man. ¶ Help us to perform them with laughter and kindly faces. ¶ Let cheerfulness abound with industry. ¶ Give us to go blithely on our Own business all this day; bring us to our resting beds Weary and Content and Undishonored; and grant us in the end the gift of sleep. AMEN!

—ROBERT LOUIS STEVENSON.

Electrification of Steam Roads

The Electrical Equipment of Terminals the Forerunner of Electrical Main-Line Operation

By RAY HAMILTON

THE electric locomotive is King! The coronation ceremonies will take place when the New York Central discards its ancient and honorable steam engines, and substitutes instead the new giants operated by that perhaps most mysterious and subtle of all forms of energy—electricity.

Exhaustive tests of both methods of traction have demonstrated unequivocally the superiority of electric over the familiar steam service in the operation of interurban railroads; and hence the signs of the times point to the complete ascendency of the former and the final elimination of the latter.

This may seem like a rash and sweeping statement; but with the experimental data at hand of past performances, and the knowledge that the engineering sciences are sufficiently exact to eliminate all probable chances of error, there seems little likelihood of any other outcome.

Evolution of the Electric Road

This long stride toward a more perfect system of transportation, had its inception when the electric street railway, as developed by Van Depoel, Sprague, Thomson, and others, was substituted for the mule some twenty years ago. So successful has been this application of the electric motor over animal power, that suburban and interurban electric roads have grown to gigantic proportions, and there are now over 30,000 miles of electric lines to less than 300 miles of horse-car lines in the United States.

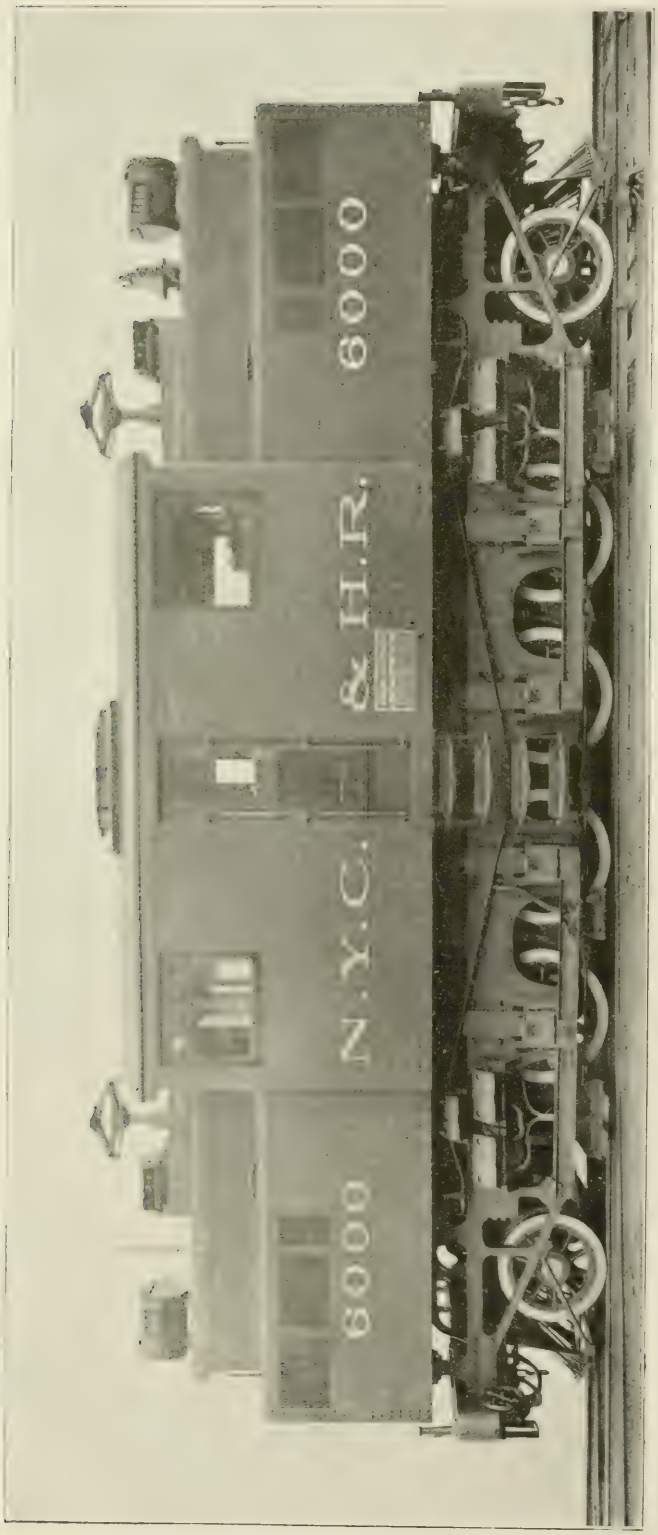
The first electrically operated elevated road was designed and put into operation by Mr. Bion J. Arnold, Past President of the American Institute of Electrical Engineers, for the World's Fair held in Chicago in 1893; and the thousands of passengers carried by that short but epoch-making "Intramural Railway" will vouch for the ideal manner in which it fulfilled its mission.

This eventually led to the dethronement of the smoky and noisy steam dummy by the silent and cleanly electrically-propelled cars on the New York and Chicago elevated roads; and, with the constant advances in electrical appliances—from the great generators in the power houses to the motors beneath the cars—the revised conditions showed a marked decrease in operating expenses and a decided increase in traffic.

New York Central Takes up the Problem

The tragedy which occurred in the tunnel of the New York Central Railroad in New York City, a couple of years ago, whereby seventeen persons lost their lives and twice that number were injured, caused the railroad company to seek ways and means to prevent a repetition of the horror. As was brought out in the official investigation that followed, the accident was due to the smoke of the passing engines obscuring the signal lights and thus preventing the engineer from seeing that these were set against him. Competent engineers, accordingly, were promptly engaged to work out the problem of a safety factor, and, unlike the proverbial doctors, they agreed that electricity would furnish the logical solution—that is, if this form of power could be operated as economically as steam. For railway corporations are not philanthropists; and back of safety, of comfort—of everything, in fact—the "almighty dollar" is the paramount issue.

But the engineers, headed by Mr. Arnold, who was commissioned by the railway company to investigate the condi-



NEW YORK CENTRAL 95-TON ELECTRIC LOCOMOTIVE NO. 6000.

tions, believed that, even in the present state of the art, the patrons of the road would not only be benefited by the improved transportation facilities which electric propulsion would provide, but that the shareholders of the company would profit by the change as well. The latter was the hook upon which the adoption of electricity really hung, and in order to substantiate their theories with actual facts it was necessary to make tests and adduce the comparative cost of operating trains by the old and the new forms of motive power.

Comparative Tests of Steam and Electricity

Though not difficult of accomplishment, the tests had to be made with exceeding care, for reputations were at stake, and an error in the calculations would have given a fatal set-back to the whole proceeding. Although both the steam and electrical deductions had been gone over a hundred times previously, they were based largely upon tests of surface and elevated roads; and while there was little probability that these would not hold good for the proposed installation on a greater scale, fresh trials on the company's own road were deemed advisable.

The first thing to be done, then, was to ascertain the amount of power required to haul the passenger trains with

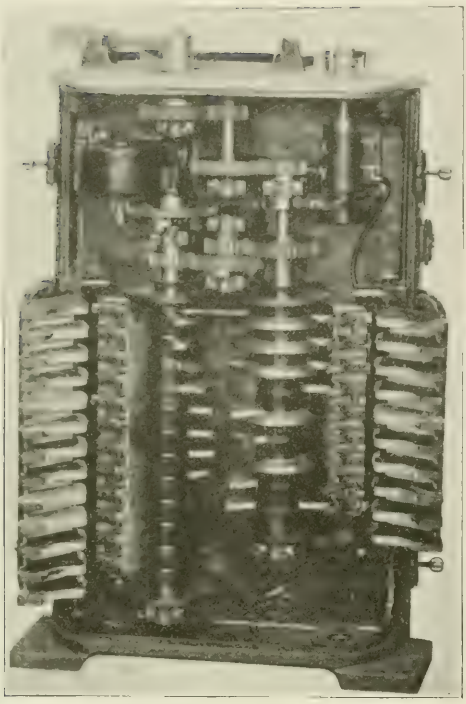
steam locomotives over the division that includes the tunnel which was the scene of the accident above referred to. The total mileage between Mott Haven Junction and Grand Central Station (Forty-second street) is five and three-tenths miles, the road being four-track, on which trains of three divisions of the New York Central and the main line of the New York, New Haven & Hartford Railroad enter New

OVERHEAD SPECIAL WORK, SUBSTATION, AND BARN, NEW YORK CENTRAL TEST TRACK.

York City. The tracks are supported on an elevated structure of steel and stone for a distance approximating two and a-half miles, then pass through the tunnel beneath Park avenue for another two miles, and finally reach the Grand Central Station through an open cut about three-fourths of a mile long.

These roads terminate in an intricate stub-end system consisting of a maze of tracks on which 600 trains are handled every twenty-four hours. With this number passing through the tunnel each and every day, the only wonder is that accidents are not more frequent, since the semaphores, the colored lights, the steam, the smoke, the whistles, and the bells are, it would seem, enough to confuse even the coolest-headed engine-driver.

There were numerous variable elements—such as the number of cars, weight of trains, track profile, degree of curvature, pull of locomotives, coal con-



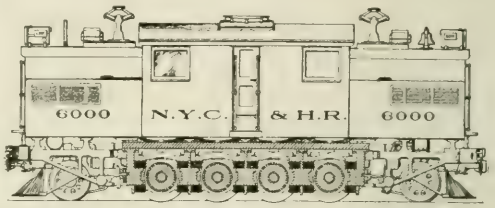
MASTER CONTROLLER.
Front view.

sumption, etc.—all of which must be known before the actual cost of operation could be arrived at. As these factors do not in any case conveniently lend themselves to determination by mathematical processes, a dynamometer car, owned jointly by the Illinois Central Railroad and the University of Illinois, was obtained for the purposes of the test.

By coupling the dynamometer car between the engine and the train, the draw-bar pull could be measured; and by making four runs with each type of train, and testing a large number of trains of different weights, the average power required for each load—the mean load of the total number of trains—was easily found. The method by which all these records were made will be easily understood from the illustrations and description of the dynamometer car and its measuring and indicating instruments.

On the dynamometer car the draw-bar is secured by means of a suitable rod to a piston-head fitting closely in a cylinder filled with oil. The pull at the draw-bar consequently produces a pressure upon this oil which is transmitted through suitable piping to the recording device. The latter consists of a Bourdon gauge. By means of an arm carrying at its extremity a pen, a tracing is made upon paper which is drawn past the pen by gearing from the car axle, in such a way that the height of the record from the base-line is proportional to the draw-bar pull.

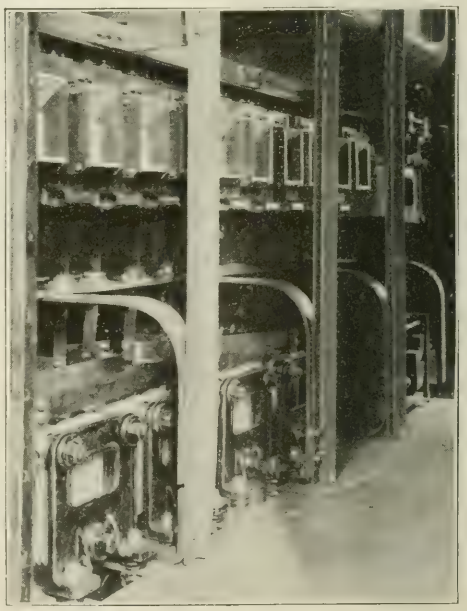
This base-line, the time and position lines, are each traced by a separate pen, the time record being made every five seconds by means of clockwork, and the



LONGITUDINAL SECTION THROUGH FRAME OF LARGE ELECTRIC LOCOMOTIVE.

position line recorded at mile-posts, stations, etc., by an electric current closed by hand.

The other instruments in use on the car during the tests were a Boyer speed recorder; an anemometer, for recording the relative velocity of the wind; and a weather vane, for showing the direction of the wind relative to the direction of travel of the car.



CONTACTORS AND RHEOSTATS IN CAB OF ELECTRIC LOCOMOTIVE.

STEAM LOCOMOTIVE USED IN ONE OF THE TESTS.

The dynamometer consists of three cylinders coupled together, the largest having an effective area of 60 square inches; the intermediate, 30 inches; and the smallest, 5 inches. This arrangement gives a working pressure of the oil in the cylinders varying from 300 to 1,000 pounds per square inch. With this range of pressure, the largest cylinder has sufficient capacity for the heaviest freight service, the next cylinder being used when testing a train of ordinary tonnage, and the smallest cylinder when working with a light train.

From the readings taken, a dynamometer car record was platted for each of the eight different classes of trains that are daily in operation over some of the divisions of the road.

The draw-bar pull of the locomotive, the speed of the train, the profile of the road, and the alignment of the track, are all included in each dynamometer car record, so that it is possible to calculate from these records, the theoretical horse-power required to haul the train under the conditions of each case, and, after equating for grade and curvature, the results can be checked from the curves obtained. These records do not indicate the power required to propel the locomotive, or the head-end resistance offered to them by the air; but these factors are taken into account when the final load diagram is determined. Thus the curves obtained illustrate graphically the power required by, and delivered by, the modern steam engine, and show what the electric locomotive will have to do in order to compete with it successfully.

There are other factors involved in the operation of trains that are of exceeding importance when the change from steam to electricity is under consideration. One that may be referred to is "braking"—that is, the stopping of a train—which is second in importance only to its acceleration or starting power, for the draw-bar pull is often as great during retardation as it is in acceleration. The braking effort of a train on its locomotive sometimes reaches as high as 11,000 pounds.

Mr. Arnold, in summing up the weights of all steam locomotives now in service on the New York and Mott Haven division, found that these could be supplanted by properly constructed electric locomotives having a total weight of 65 tons each. By a careful analysis of the choice of systems, reviews of plans, cost of installation, operating expenses, and fixed charges per annum, besides many lesser details, he also ascertained the relative cost of steam and electrical operation, which is presented in the following table:

EXTERIOR OF DYNAMOMETER CAR.

RELATIVE COST OF OPERATION BY STEAM AND ELECTRICITY.

	STEAM	ELECTRICITY
Operating expenses per locomotive mile, exclusive of fixed charges, but including water, labor, cost of cleaning and repairing tunnel, and all other expenses of locomotive operation	Cents 23.05	Cents 15.80
Fixed charges per locomotive mile, assuming that it now requires 40 locomotives to perform the present service, and that 33 electric locomotives could perform the same service	1.13	7.83
Total (in cents)	24.18	23.63

While the saving to be effected in the operation of an electrified road over one using steam is not, according to the above figures, very great, it must be remembered that the conclusions reached in regard to electric traction are very conservative; and when the service begins, it will in all probability mark a very much greater economy than the table here given indicates.

During the summer of 1903, Mr. William J. Wilgus, Fifth Vice-President of the New York Central Railroad, witnessed a number of tests then being made by the General Electric Company at Schenectady with a new type of electric locomotive just finished for heavy freight traffic through the Baltimore tunnel of the Baltimore & Ohio Railroad, and these showed the great power of the electric traction system. Comparative tests were then made by Messrs. B. J. Arnold and W. B. Potter on the experimental track of the General Electric Company, for the purpose of determining the relative values of braking and acceleration between steam and electric traction on short-haul suburban passenger service.

Owing to the short curves of the General Electric Company's tracks, the steam tests were made on the New York Central tracks west of Schenectady. In both the steam and electric tests, a train of six cars, made up of five standard passenger coaches and the dynamometer car, was run over a mile of track, acceleration being made as rapidly as possible with the power available. From the tables then prepared, it was clearly demonstrated that electric motors can much more efficiently utilize the weight upon their drivers during the starting period than can a steam locomotive. In consideration of these exhaustive tests, in which electricity was shown in every way to be superior to steam, the New York Central decided to electrify its first division, and placed a contract for an experimental electric locomotive to be built by the General

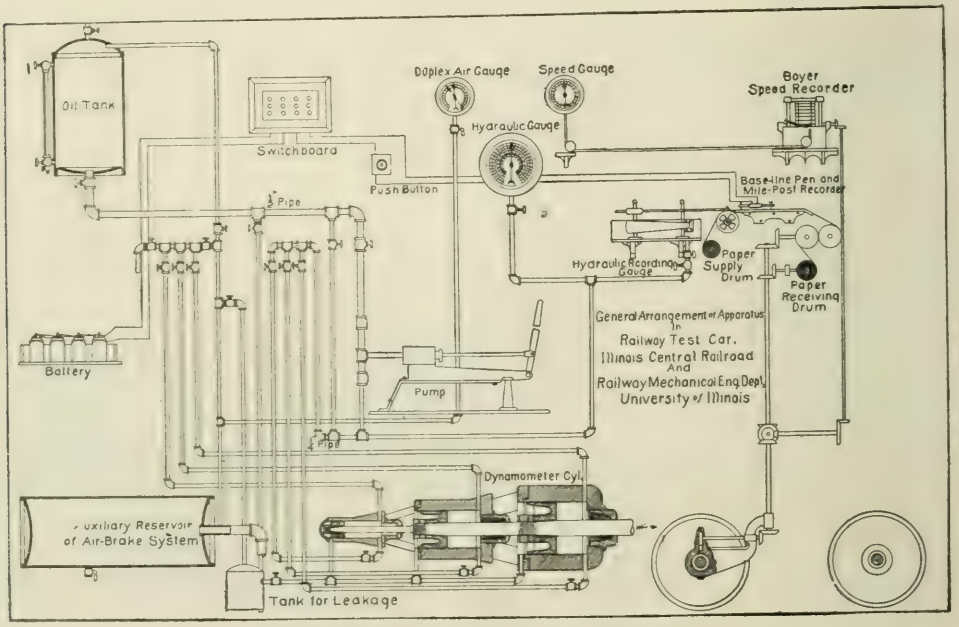


DIAGRAM OF APPARATUS IN TEST CAR.

Electric Company. Third-rail track construction and power-house installation were also begun, the total expenditures, when the electrification of the division was completed, to be approximately $10,000,000.

While it was and still is the opinion of nearly all electrical engineers that the alternating-current motor will in a short time supersede the direct-current motor for long-distance railroading, Mr. Arnold, in his report, recommended that, inasmuch as the alternating-current motor could not start under load as efficiently, or accelerate a train as rapidly, as a direct-current motor, and inasmuch as the division to be electrified was short, the trains many, and rapid starting essential, the direct-current system should be adopted.

The frame of the locomotive, which is made of steel, serves as a portion of the magnets for the fields of the motors. On this frame, motors capable of developing 3,000 horse-power are supported, the armatures, or revolving elements, forming a part of the four driving axles and thus obviating the necessity for gearing, which would otherwise be required. The electric locomotive as it stands on the track, weighs ninety-five tons.

INTERIOR OF DYNAMOMETER CAR.

No. 6000

Hence the trial locomotive recently completed was built of the direct-current type. Tests of the new monster took place between Schenectady and Hoffman's on November 12, 1904, where the General Electric's experimental track and the New York Central tracks parallel one another for some little distance.

The long experience of engineers in the design of high-speed locomotives, has been incorporated in the new electric locomotive; and with its simplicity, direct drive, and multiple-unit control, the highest efficiency is guaranteed.

Another feature worthy of notice is the absence of "pounding" caused by the reciprocating motion in a steam locomotive. This insures a considerable reduction in the expense of maintaining the track and roadbed in good condition.

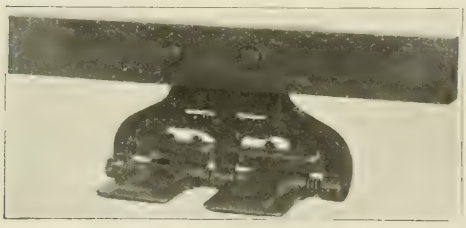
One more element of excellence is the adoption of a system of control known as the "Sprague-General Electric multiple-unit system," this term implying that two or more of the locomotives may be coupled together, giving double the power but admitting of operation by a

single motorman just as though they had been bunched into a single unit.

The New York Central electric locomotive No. 6000, with its train, is shown herewith, the exciting race between it and the fast mail, the "New Yorker," being vividly depicted.

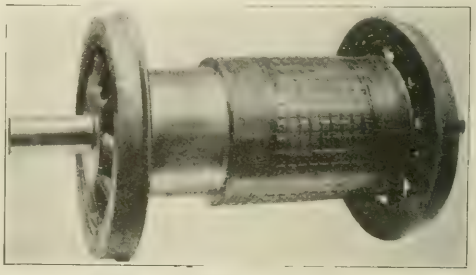
When the "New Yorker" with its seven coaches came speeding by at the rate of a mile a minute, the electric locomotive was leisurely drawing a train of five cars, making a mile every two minutes; more power was developed, not by stoking a furnace with coal, but by merely moving the lever of the master controller; and before another mile-post had been reached, the two trains were abreast. There was yet plenty of power in reserve; and the slipping of the lever a few more notches, produced, to the observer in the cab of the electric locomotive, the weird effect of running away from a train making sixty miles an hour. Soon the "New Yorker" was left behind several train-lengths, the gauge showing that a speed of seventy miles an hour had been easily made.

NO. 6000 DOING SEVENTY MILES AN HOUR.



THIRD-RAIL SHOE.

To the technical experts of the New York Central, the tests were eminently satisfactory, and fifty or more locomotives of the same type will be built as rapidly as possible. While it was intended at first to equip only the New York and Mott Haven division, it has now been decided to electrify the road as far as Croton, thirty-four miles out on the main line, and to White Plains, twenty-four



ARMATURE, AXLE, AND WHEELS (ASSEMBLED) FOR HEAVY ELECTRIC LOCOMOTIVE.

miles out on the Harlem division. The change from steam to electricity will probably be completely effected in the fall of 1906.

Electrification Extending

The electrification of other railroads this year will include the Atlantic and Rockaway Beach division of the Long Island Railroad, between Brooklyn and Rockaway Beach. The great work on the tunnel and terminal system of the Pennsylvania, New York & Long Island Railroad is rapidly going on; but the task is of such gigantic proportions that it will be several years before the electric passenger service will be in operation. The New York, New Haven & Hartford Railroad will also substitute electricity for steam to facilitate the movement of its suburban passenger traffic.

It has been shown by Mr. Ralph Mershon that the transmission of electrical energy to a distance of at least 500 miles is perfectly feasible; and, with the great hydro-electric plants now building at Niagara Falls, from which, when finished, a million electrical horse-power will be available, it would not be strange if a suitable system of electrical propulsion for the complete operation of those roads now connecting New York City with Buffalo should at no distant date be forthcoming. The relatively cheap power thus obtainable is assuredly capable of fulfilling the conditions imposed by the conversion of steam-operated into electrically operated railroad systems.

The Worth of Toil

THE noblest men I know on earth,
Are men whose hands are brown with toil;
Who, backed by no ancestral graves,
Hew down the woods and till the soil,
And win thereby a prouder fame
Than follows King's or warrior's name.

The workingmen, whate'er their task—
To carve the stone or bear the hod—
They wear upon their honest brows
The royal stamp and seal of God!
And brighter are their drops of sweat
Than diamonds in a coronet!

God bless the noble workingmen,
Who rear the cities of the plain,
Who dig the mines and build the ships,
And drive the commerce of the main.
God bless them! for their swarthy hands
Have wrought the glory of our lands.

JAPANESE VILLAGE WRECKED BY EARTHQUAKE.
Over one thousand earthquakes traverse the Island Empire annually.

Our Earthquake Survey

How the Mysterious Convulsions of the Earth's Crust are Detected and Measured—A Hitherto but Little Explored Field of Applied Science

By JOHN ELFRETH WATKINS

AN earthquake survey of the United States and its possessions is one of the most recent enterprises of science.

Seismologists—the students of these phenomena—are learning that Mother Earth is a much more tremulous creature than we have previously had reason to suppose. In fact it would almost appear that she is growing palsied as the chill of old age creeps over her.

If it is not straining imagination too much, it may be said that these seismologists are setting earthquake traps in various nooks and corners of our vast domain. These are among the most sensitive products of the instrument maker's fine art. They have a much more acute sense of touch than has been given to man. In fact, they would almost seem to have been endowed with brains, for they automatically write with pen and ink all that they observe, and their records are kept with a superhuman exactitude.

Seismographs Installed

The Government recently purchased in Germany six sets of the most improved apparatus of this category. These, known as "seismographs" or "seismoscopes," have been installed at Washington, D. C.; Cheltenham, Md.; Baldwin, Kan.; Vieques Island, Porto Rico; Honolulu, Hawaii; and Sitka, Alaska.

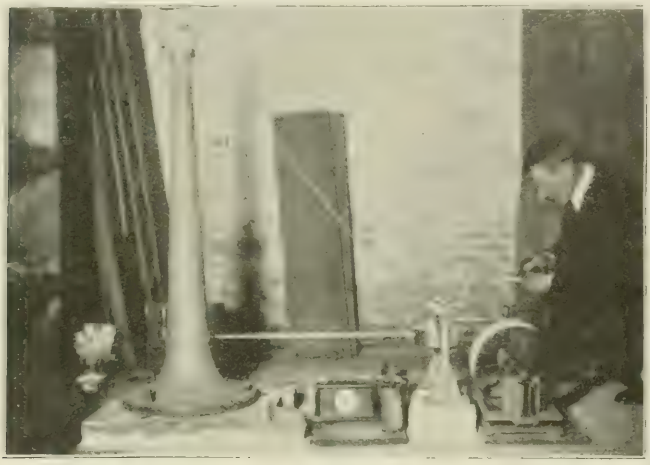
The Washington instruments are installed in a subterranean vault beneath the Weather Bureau, where they are in charge of C. F. Marvin, Professor of Meteorology in that institution. The other five sets have just been put in place in the new federal magnetic observatories at the other points named. They are being operated under the general direction of Dr. L. A. Bauer, Chief of the

Division of Terrestrial Magnetism, United States Coast and Geodetic Survey. Added to this chain of stations, are others at Manila, Philadelphia, and Baltimore. The first-named is in charge of Father Algue, a Jesuit scientist of the Manila Observatory. The Quaker City's station is at Swarthmore College; and that of Baltimore, at Johns Hopkins University, where it is under the direction of Prof. H. F. Reid, the most eminent of American seismologists. Professor Reid's station is serving as the clearing house, so to speak, for all of the American earthquake data; and, as soon as the co-operating stations shall have completed a sufficient continuous period of observation, he will issue statistics which no doubt will surprise us all.

THE GREAT EARTHQUAKE AT CHARLESTON, SOUTH CAROLINA, AUGUST 31, 1886.
Street scene just after the severest shock.

Foreign stations, also, are co-operating in this work, particularly those at Toronto, Ont., and Victoria, B. C., under the meteorological establishment of Canada; and others at Mexico City; Cordoba, Argentina; and Arequipa, Peru. In fact, arrangements are being effected,

looking to the perfection of an earthquake survey of the world under the auspices of the International Seismological Association. This society has been organized for this special purpose under the leadership of Professor Gerland, Director of the Seismological Observatory at Strassburg, Germany. Japan will fall into line with nearly 1,000 stations; Italy, with 15; England, with 3; Scotland, 2; India, 4; Canada, 2; Australia, 3; Russia, 3; and Spain, 2; also South Africa, Egypt, Ceylon, Java, Mauritius, New Zealand, Syria, Trinidad, Mexico, Peru, Argentina, and Germany, each 1. Thus Old Earth will have left but few surface areas where she may twitch undetected.



New Type of Seismograph Adopted for Government Stations.

But, as to our own earthquake survey:—The six seismoscopes which we have installed are regarded as the most perfect of their class. The pattern is a modification of the recent invention of Professor Omori, secretary of the earthquake investigation committee of Japan. Japan is the great earthquake country, and has gone so far as to institute a chair in seismology at the University of Tokio.

How the Records are Made

This new type of seismograph consists of a heavy weight, so suspended in front of a tall iron pedestal as to be always in neutral equilibrium and unaffected by any influence other than gravity. While the earth is quaking and trembling directly below it, it is standing still for the moment. It is spanned by an iron arch, whose base is a stone pier, penetrating the earth. All earth movements are directly communicated to the arch. Hence, when even the slightest tremor takes place, the arch moves therewith, but the weight below remains quiescent, as already said.

Attached to the stationary weight by a jeweled pivot, is a long, slender arm of aluminum, with a writing pen at its outer end. Upon the same foundation with the arch, and sharing all earth movements therewith, is a revolving wheel whose broad tire is a sheet of paper, against which the writing pen rests. The principle of the instrument, in a nutshell, is that each earthquake moves the paper against the pen, and records its tremors in zig-zags or curves. But, by a delicate adjustment, the aluminum arm exaggerates the earthquake tremor to a measurable degree.

The wheel, with its paper tire, makes one revolution every hour. The recording pen commences its record on one edge, and, by aid of a thread on the wheel's axle, is made to trace gradually a perfect spiral over the endless band of paper, unless an earthquake interrupts. Thus the normal lines of the pen do not overlap. By means of an electromagnet attached to a specially made clock, a current is communicated every minute to another pen point, following the first and resting upon the same paper. The latter gives a hitch each time it receives an electric impulse, and thus checks off minutes along the spiral line traced by the first pen, which is "keeping tab" on Mother Earth's antics. A new paper is placed on the wheel at the same minute each day. It being known precisely when a new record is set, the exact time of a zig-zag earthquake line can be determined by counting the minute marks on the paper; and the exact

second of an earth tremor's beginning can be learned by applying a delicate scale dividing by sixty the space between two minute marks.

A pair of these instruments is necessary at each station. One, always pointed north and south, records earthquake vibrations moving east and west; the other, directed east and west, detects north and south movements. Each tremor makes its record on both instruments simultaneously. The zig-zag lines will be seen to differ materially when the paper strips are taken from the wheels and carefully compared with a scale. The exact direction of the earthquake wave, as well as its horizontal width, is thus measured to a nicety.

Delicacy of the Work

Only one out of several hundred or perhaps several thousand earthquakes recorded by these instruments, is perceptible to the public or reported by the newspapers. Typical of these earthquakes noticed month after month, was one caught by the Weather Bureau's seismograph just after its installation. On looking over the record sheets at the time of the daily change, Professor Marvin discovered a zig-zag perfectly inscribed and showing all the recognized characteristics of earthquake phenomena. The curve showed that there were preliminary tremors commencing at 9:29 A. M. and lasting five minutes. The main tremors then succeeded for 2 minutes 36 seconds. Terminal tremors lasted for 26 minutes 24 seconds. The total disturbance lasted 34 minutes. At the height of its activity, the earth beneath the instrument moved only a trifle more than a hundredth of an inch, from side to side. Small wonder, then, that the public was unaware of the shock.

But this tiny earthquake, undiscovered by press or public, traveled across the continent and was felt on the Pacific slope by a similar seismograph. Without announcing the fact that his instruments had recorded the shock, Professor Marvin filed their records away and corresponded with other stations. He found that those of Baltimore, Victoria, and Toronto had recorded the shock at about the same time. By careful computation, he discovered that its first strong waves traveled from Victoria across the continent to Toronto in a fraction over eighteen minutes, and from Toronto to Washington in one and one-half minutes. The stronger waves traveled at the rate of nearly two miles per second.

That earthquakes will some day be systematically forecast, is a prophecy which may sound visionary, but one which has some scientific foundation. The Japanese seismologists now believe that they find indications of earthquakes' approaches upon the records of their magnetic instruments, preceding directly the effects shown by their seismographs. In other words, they have found what appear to be magnetic warnings of earthquakes. If their theory can be demonstrated, our Weather Bureau will doubtless profit by it; and we may expect, perchance, to see earthquake warnings displayed from mastheads above our public buildings, or to read at the top of the morning paper that Mother Earth will indulge in a shake-up at such or such an hour of the day. Pastors may then have time to gather in their flocks for public prayer, or urban residents may betake themselves to the open country, before the crash comes.

"Craterlet" Caused by Charleston Earthquake.

Frequency of Earthquakes

In 1904, at Baltimore, fifteen earthquakes were recorded by Professor Reid between April 1 and October 21. In Porto Rico, seventeen were observed by the national instruments between April 1 and July 1; in Honolulu, thirteen were counted within this latter period. According to these figures—upon the basis of which it is hardly fair to generalize, however—an earthquake shakes our Eastern States on an average once every two weeks, while the frequency is considerably greater both in Hawaii and in Porto Rico. The national instruments have not been installed a sufficient time for any statistics to have been gathered elsewhere.

Earthquakes and magnetic storms are found to be related, and it is partly for this reason that the Government's new magnetic observatories are being equipped with seismographs.

FISSURE CAUSED BY CHARLESTON EARTHQUAKE.

The primary object of the national earthquake survey will be the determination of the velocity with which shocks

and vibrations are propagated over the surface of the earth and through its interior; to locate positions of earthquake origins under the oceans; and, generally, to increase our knowledge of the physical nature of the earth's crust and its interior.

The average velocity of earthquakes, as thus far estimated, is about 1¼ miles per second for the first tremors, and about 1 mile per second for the main shock. After a few hundred miles, the velocity of the first tremors increases, and

ONE OF THE VARIED PHASES OF EARTHQUAKE EFFECTS.
Here an area was depressed 25 feet below its former level, leaving a terrace 25 feet high.—View taken in Japan.

over long distances has been estimated to be greater than that of the waves of compression through steel or glass. The fact that the vibrations of the first tremors appear to travel faster than those of the main shock, indicates that the former pass directly through the earth, while the latter follow the longer course around its crust.

Mother Earth appears to quake, at some point or other, on an average, once every half hour. In Japan, more than a thousand earthquakes per year are regularly recorded. Great Britain's dominions are crossed by tremors about 100 times a year. For our own country, we have no complete figures as yet.

In both hemispheres, according to such statistics as are now available, earthquakes are more frequent in winter than in summer. This is believed to be due to the fact that in the cold season the greater weight of snow and the greater pressure of the atmosphere imposes a heavier strain upon the earth's crust.

How Earthquakes Operate

In many instances, shocks so faint that they cannot be perceived by our senses when we are upon or near the ground, are distinctly felt upon the top floors of tall buildings. Severe shocks are accompanied usually with sounds comparable to those of near or distant explosions. Other effects of great earthquakes are fissures and faults in the earth's surface; the raising or lowering of areas of ground; the drying of springs; landslides, land waves, and tidal waves. The fissures in the earth's surface may open widely, and immediately close, or they may remain open with a width of several feet. Some have had such immeasurable depth that water from streams has flowed into them for days without filling them, while others have belched up gases, water, or mud, appearing as if from the crater of some slight volcano. Sometimes large areas of land are depressed, forming the basins of new lakes; and in frequent instances a large area of land

HOW AN EARTHQUAKE MAY AFFECT STRAIGHT RAILWAY TRACK.
View taken in Japan.

has fallen to a lower level, leaving a definite wall or terrace between it and the soil not so affected. These severe shocks sometimes precipitate boulders down mountain slopes, or cause landslides or avalanches that bury settlements of people or throw dams across streams, creating lakes where none before existed.

Subterranean earthquakes are observed to give rise to surface waves similar in formation to those caused by dropping a pebble into a brook, but much more enormous in height, and often attaining the fatal form of a tidal wave washing inland and drowning hundreds of people. Luminous appearances have been reported as accompanying earthquakes occurring at night; and it is thought by some that these phenomena are due to the friction of moving masses of rock. According to this theory, temporary electric currents are, as a result of such friction, established in the line of the earthquake. At or near the starting point of great earthquakes, there is sometimes evidence of the bodily displacement of many cubic miles of material. When this matter is of volcanic origin, it is, according to one authority, almost invariably magnetic, and its readjustment produces magnetic storms.

Historic American Earthquakes

Our most notable earthquakes have been those occurring in New England, in 1638; New England and New York, 1663; New England, 1727; New England and the North Atlantic States, 1755; the Mississippi delta, 1811-12; Inyo Valley, California, 1872; and Charleston, S. C., 1886.

The earliest of these—on June 1, 1638—occurred between 3 and 4 P. M. The weather was clear and warm, and the wind westerly. All of New England, it is recorded, was violently shaken by a convulsion accompanied with a noise as of continued thunder. The main shock lasted about four minutes, during which the earth shook with such violence that in some places people could stand only with difficulty, while many movable articles in houses were thrown down. The earth is reported to have been unquiet for twenty days following this shock.

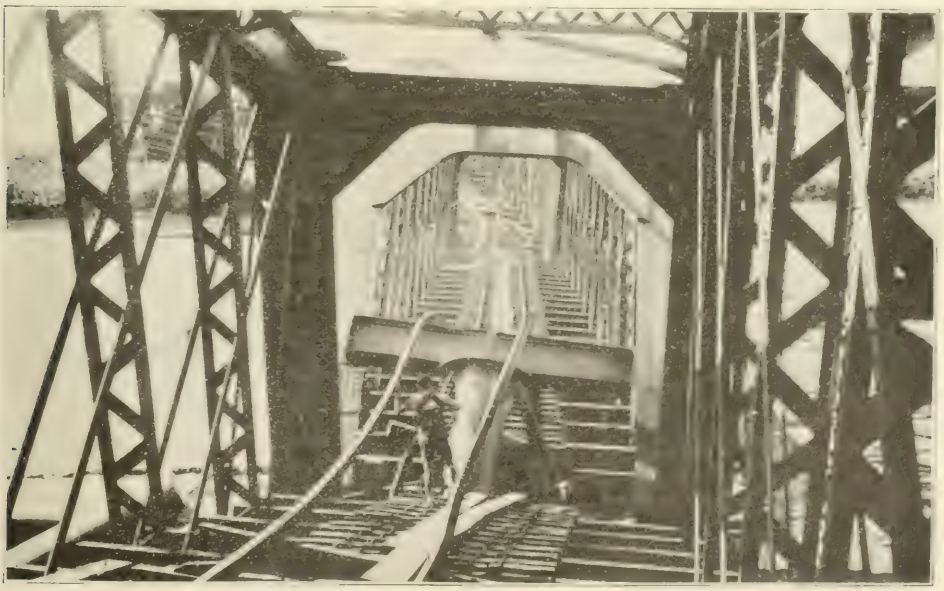
The earthquake of 1663 occurred on January 26, and was felt in Canada, throughout New England, and in New York. In Canada, says a contemporaneous writer, "Doors opened and shut of themselves with a fearful clattering. Bells rang without being touched. Walls were split asunder. Floors separated and fell down. The fields put on the appearance of precipices, and the mountains seemed to be moving out of their places." It is recorded that during this convulsion of nature, small rivers were dried up; some mountains appeared to be much

broken and moved; while half way between Quebec and Tadousac, at the mouth of the Saguenay, two mountains were shaken down, forming a point of land which extended some distance into the St. Lawrence River.

The upheaval of 1727 was felt at 10:40 A. M., October 29. The main shock lasted about two minutes; and its course seemed to be from the Delaware River to the Kennebec, a distance of about 700 miles. Pewter and china were cast from their shelves. Stone walls and chimney tops were shaken down. In some places doors were burst open and people could hardly keep their feet. On the same day, the West Indian island of Martinique—where in 1902 occurred the terrible eruption of Mont Pelée—was threatened with total destruction by an earthquake lasting eleven hours. And in this connection it is an interesting fact, that during the recent disastrous outburst of Mont Pelée, no earthquake shocks were recorded by the crude seismograph then mounted in the Weather Bureau at Washington, although severe magnetic storms were observed with the instruments of the Coast and Geodetic Survey.

The earthquake of 1755 was felt from Chesapeake Bay to the coast of Nova Scotia—or for about 800 miles. The shock occurred on November 18, and in the interior of the country it seemed to have extended over a thousand miles from northwest to southeast. In Boston, Mass., a hundred chimneys were toppled over and leveled with the roofs of the houses, while 1,500 others were more or less shattered. The ends of several brick buildings were thrown down, and the vane on the public market was hurled to the earth. At New Haven, Conn., it was reported, "the ground moved like waves of the sea; the houses shook and cracked; and many chimneys were thrown down." This shock occurred at 4:00 A. M., and lasted four and a-half minutes. At the same time there was a great tidal wave in the West Indies.

The Mississippi delta earthquake of 1811-12, known also as the "New Madrid earthquake," was characterized by severe shocks occurring at short intervals during a period of several months. Indeed the entire series of shocks covered a period of about two years. There were few settlers in the country at that early day, and little is known as to the distance at which the shocks were perceptible. The land was plainly seen to rock with a wave-like motion, which was communicated to the forest trees, some of which were uprooted while others were permanently entangled with one another. From the fissures opened into the earth, mud



EFFECT OF AN EARTHQUAKE UPON A JAPANESE RAILWAY BRIDGE.

spurted up into the branches of trees, and the deep openings into the ground yawned and closed with each successive shock. Lakes which had sparkled in the sunlight of centuries went out of existence, their waters being drained into these fissures. New lakes were created by the falling of the land, which was thus shaped into basins receiving the flow of brooks and creeks. One great area 60 to 80 miles long and half as broad, sank from its former altitude.

The Inyo Valley earthquake of 1872 continued for two or three months. The chief shock lasted but a few minutes, and those which followed at intervals were far inferior in violence. Along the base of the mountain range, was created a fissure forty miles long, and the land to the east of it fell several feet. In one place the earth dropped twenty-five feet. The ground also twisted in a horizontal direction. The fence on one piece of property was found to be fourteen feet out of alignment. A river was temporarily swallowed, and a number of springs permanently dried up. Every house in Inyo village tumbled down, and one-tenth of the inhabitants lost their lives.

Twenty-seven people were killed outright by the great earthquake at Charleston, South Carolina, August 31, 1886. Other victims died afterward from injuries received during the catastrophe. A large number of houses were thrown down, and nearly all buildings in the city were more or less injured. The damage to property was computed in millions of dollars. The principal shock occupied about one minute, others following with diminishing violence. Destructive tremors occurred for four weeks, and others were felt for several months longer. Numerous fissures yawned in the surrounding country, sending forth water and mud and flooding the channels of streams. Railway tracks were dislocated and buckled.

DEVASTATION WROUGHT BY A JAPANESE EARTHQUAKE.
"Japan is the great earthquake country."

Had adequate seismographs been in place during any of these great earthquakes, science would have added greatly to its meager fund of knowledge concerning the cause of such convulsions. The next great shock will be followed about the earth, and, it is devoutly hoped, will be traced to its subterranean source.

The Vertical Milling Machine

An Indispensable Part of Machine-Shop Equipment Adaptable to a Very Wide Range of Work

By HORACE E. SWIFT

AMONG the many new machines that have been built and put on the market within the last decade and a-half, we doubt if any has become more indispensable to the manufacturer of machinery of every description than the Vertical Milling Machine. Its advantages over even the latest designs of the horizontal type are now universally recognized for many classes of manufactured work. For finishing surfaces—usually done on the planer or shaper or in the lathe—the vertical milling machine fills a place in general manufacturing plants with absolute success. For circular or straight work, for finishing surfaces both horizontal and vertical that are either difficult or impossible to get at with lathe or planer, the vertical machine has no equal. It is impossible to exaggerate its utility as an economizer of labor and as a producer of work impossible to perform with other tools.

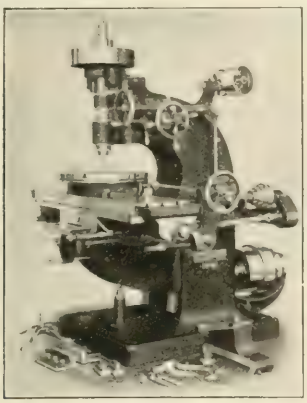


FIG. 1. MODERN VERTICAL MILLING MACHINE.

In Fig. 2 is shown a twelve-inch inserted-tooth face mill roughing off a plane surface, and this also shows the correct practice in using cutters of this kind on a vertical machine. The cutter is fitted to the nose of the spindle, which secures great rigidity. Its economy over a planer in this class of work is from three (and even more) to one; and if the parts have to be scraped to a fit or a finish, the labor is reduced in like proportion.

On the other hand, if it is necessary to cut into the recess in the center of the casting, a cutter similar to that shown in

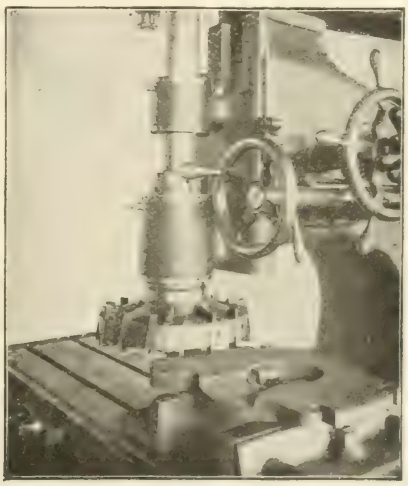


FIG. 2. FACING A PLANE SURFACE WITH INSERTED-TOOTH TOOL.

Fig. 3 could be used. This style of tool on a vertical milling machine is what might be called a "universal cutter," or "end-and-side" mill; and Fig. 3 shows how it is used on what would be an awkward job to do on the planer. It matters not whether the end of the table to be milled is one or six inches thick; at the lowest estimate the planer is the loser, three to one. If, for instance, the piece is comparatively short, and requires finishing on both ends, no change of tools is necessary, the table being simply

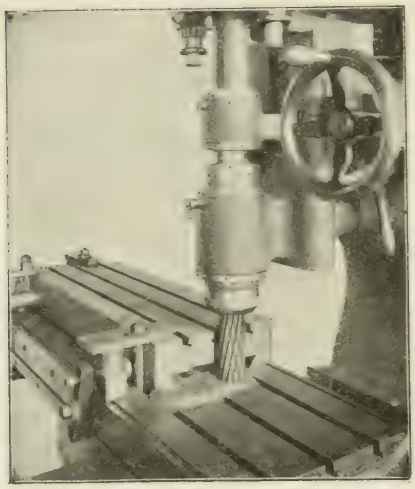


FIG. 3. UNIVERSAL CUTTER FOR END-AND-SIDE MILLING.

moved along until the other end of the piece is in position to be milled to its proper dimensions.

The advantage on small pieces, as shown in Fig. 4, is manifest; and the same style of cutter, if used as a combined end-and-side mill, will do more in one hour than could be accomplished by a shaper in six hours. This class of work as a rule uses up much time on machines that could be employed to better economy on other and larger work; while the fact that the same tool can be used for working on either side or the surface without change, recommends vertical milling to the up-to-date manufacturer.

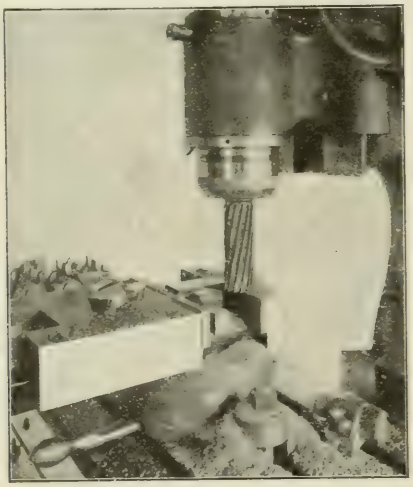


FIG. 4. SMALL PARTS RAPIDLY FINISHED IN VERTICAL MILLING MACHINE.

Milling or planing spots that come at irregular intervals or at right angles with each other, has never been a practical operation in the general run of work found in machine shops. The work is usually done by hand, or, when required to be of a better finish, is counter-bored. Take for instance a bracket, as shown in Fig. 5, with spots to be finished on both ends, on the inside, at different levels and at right angles with each other—a difficult subject to handle by any method other than the use of a vertical milling machine. This class of work can be done at an economy of four to one over any other method, with a saving of time on all subsequent operations; and it also in-

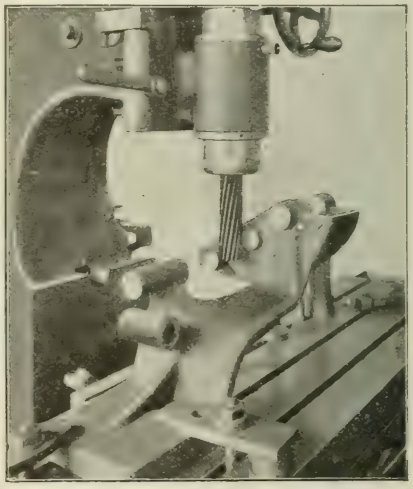


FIG. 5. FACING SPOTS AT IRREGULAR INTERVALS AND AT RIGHT ANGLES.

sures all surfaces being parallel or square with each other, without changing the setting of the work.

Economy Ten to One

On the piece shown in Fig. 6, the same style of cutter could be used for finishing spots on the inside surface of a casting, or for finishing the top edge of the casting, or the top and sides of the plate, by which it is fastened to the machine. In the hands of a skillful workman, even the outside irregular surface could be easily finished with an economy over any other method, of ten to one.

The universal use of the end-and-side mill in the vertical milling machine is strikingly shown in Fig. 7, where one is

used in finishing a horizontal plane surface and the vertical segment of an arc, at one operation and in one-tenth of the time required in a lathe.

An end-and-side mill should as a rule be made with special flutes; and, if over one and one-half inches in diameter, it would be of advantage to have the teeth nicked; to break up the chips.

Two examples of angular milling are shown in Figs. 8 and 9; and in each case

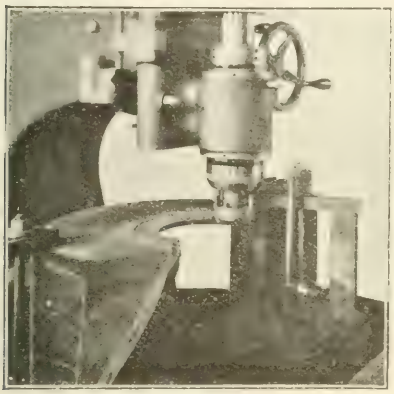


Fig. 6. Finishing Inside Edge of Casting.

it may be noticed that there are vertical surfaces to be milled, and also horizontal edges to be finished. These are taken care of, first, by the use of the end-and-side mill shown standing on the table in Fig. 9; and then the angular or dovetail mill is substituted, and the under-cut is made. One can readily see that there

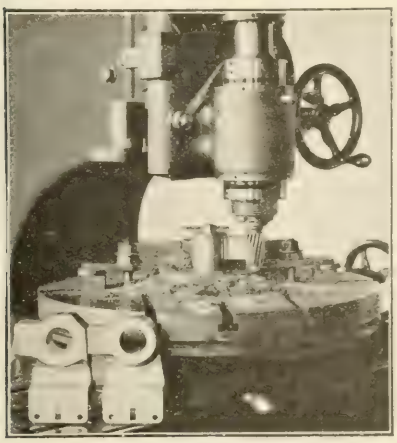


Fig. 7. Finishing Horizontal Plane and Vertical Curve at One Operation.

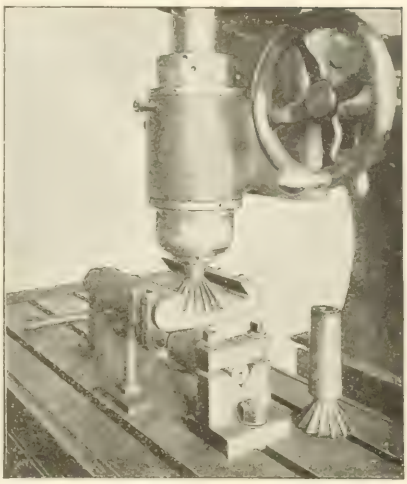


Fig. 8. An Example of Angular Milling.

is no end to the work of this kind that can be done—slotting in places absolutely inaccessible to ordinary methods; undercutting and bevel or dovetail work in straight line or circle; and inside profile work, either freehand or by the use of profile pattern gauges. Some of this work can be done by no other method on a machine, and, until the advent of the vertical milling machine, was done by hand. The saving in time on such

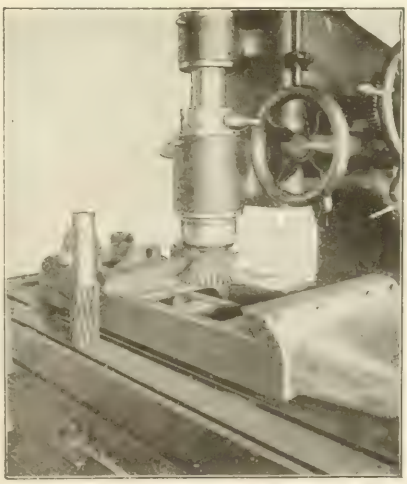


Fig. 9. Vertical, Horizontal, and Angular Milling with Two Tools.

work will cover the expense of the machine in a comparatively short time, let alone the accuracy and amount of the work performed.

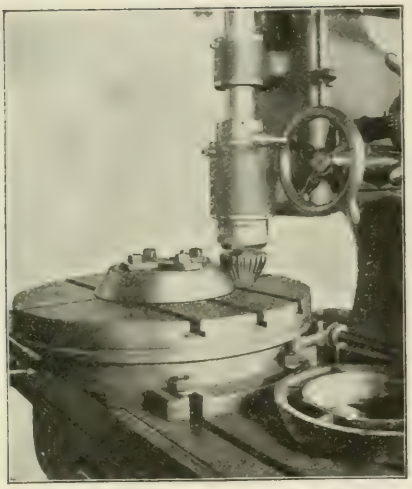


Fig. 10. Circular Bevel Milling.

Circular Milling

Fig. 10 shows an example of outside and inside bevel circular milling; and the piece lying on the platen shows also a circular recess done by the end-and-side mill. In fact, all the finish on this piece—top, bottom, inside, and outside—has been done by the use of the bevel and the end-and-side mill, on a power-driven rotary table, at a saving over the method of turning on a lathe, of four-fifths of the cost.

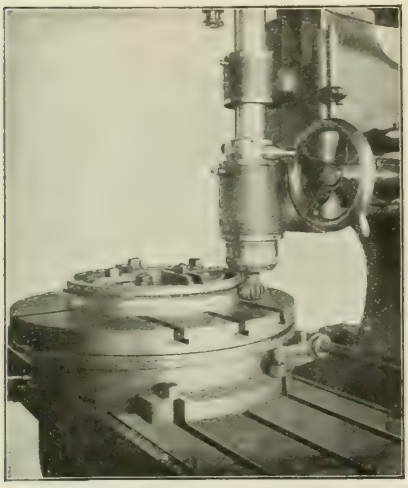


Fig. 11. Ball Cutter Used with Rotary Table.

The T-slots in the rotary table are done with a T-slot cutter. The ball cutter used in connection with the rotary table is shown in Fig. 11; and it can be readily seen how the handle, which is connected with the vertical feed of the head, is finished by the use of a concave mill. By using a universal dividing head, all the usual work done on the horizontal milling machine can be done. Fig. 12 shows the method of cutting the slots in the blank for an inserted-tooth cutter to be used on the vertical milling machine.

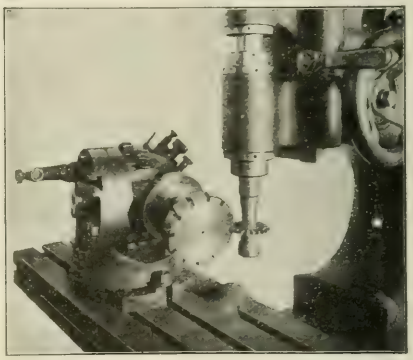
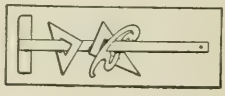


Fig. 12. Method of Cutting Slots around Edge of Blank.

The use of the vertical milling machine seems to be growing more and more in favor with manufacturers of machinery and hardware sundries. The writer has in mind a case where a large door-frame for a boiler front was to be faced off, and the door milled to fit. The old method was to chip and file until the fit was made, which required nearly three hours' labor for one man. By the use of the vertical milling machine the time was reduced to about twenty minutes. This is only one of many thousands of cases where the supremacy of this machine is so apparent that manufacturers have been obliged either to introduce it as a money-saver in their factories or to continue to be classed as behind the times.



THE MAIN GUN-SHOP.
View Looking South from Gallery.

U. S. Naval Gun Factory

Details of Manufacture of the Great and Secondary Guns Used in the Navy and for Coast Defense

By ROBERT G. SKERRETT

Formerly of the Navy Department, Washington, D. C.

NO work connected with the fashioning and equipping of our fighting craft is more interesting than that importantly contributive share borne by the United States Naval Gun Factory at Washington, D. C. What this share really means, is understood only by relatively few of our millions of citizens; and this lack of knowledge is peculiarly wide, for, during the last session of Congress, one of the members of the Naval Committee of the House of Representatives was surprised to learn that this great factory was actually within sight of the Capitol itself.

The Gun Factory not only makes most of the guns for our ships, but keeps the vast bulk of them in repair, and, in addition to this, manufactures all of the experimental guns and appliances used in connection with the research work at the Naval Proving Ground at Indian Head, Maryland. During the fiscal year 1903, the cost of labor alone was $5,128,550, while the value of the materials used was quite a third more. At the present time, the Factory employs about 4,000 men, and the majority of these are skilled mechanics of a high order of attainments. The scope of the work covers substantially the entire field of ordnance production, save that of making the steel forgings from which the guns are fabricated, and the manufacture of powder and projectiles. To the great steel manufactories of the country, due credit must be given for supplying the big, high-grade forgings demanded in this field of mechanical industry; and, in no small measure, the growing effectiveness of our ord-

nance, pound for pound of mass, is to be credited to the discoveries and advances made by the steel works and their metallurgists.

In no other field of mechanical labor involving the handling of similar masses of metal, is there demanded the same nice regard for the minutest fractions of an inch. Ponderous bodies weighing more than half a hundred tons are put together with a scrupulous exactness of a thousandth of an inch, that the weapons, in turn, may hurl safely their harmonized missiles of steel against an enemy's defense with the murderous rap of *thousands* of tons.

So great has grown the demand for guns—ships being authorized more rapidly than their armaments could be turned out by the present plant—that it has become necessary for the Navy Department to have some of the 8-inch rifles and those of lesser calibers built at the Army Gun Factory and by some of the big steel works, now fitted with ordnance tools. Of the largest guns—those that form the main reliance of our line of battle—all are built at the Naval Gun Factory. These are guns of 10-, 12-, and 13-inch calibers—the last-mentioned being considered now somewhat out of date.

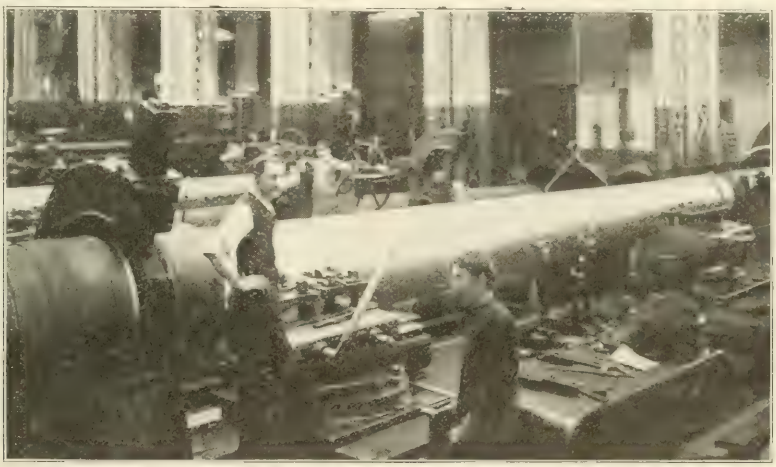
During the fiscal year 1903, the Factory turned out no fewer than 150 new guns of various calibers—65 of them being of 6-inch caliber and upwards. Besides these new guns, the Factory converted 11 guns and refitted no fewer than 46 guns of older pattern. During the same period, or rather at the close of the fiscal year mentioned, the Factory had under construction 681 new guns, of which a good share have now been completed. To handle this immense mass of work—and to appreciate the labor involved, one must live in the midst of it day in and day out—the employees are divided into three shifts of eight hours each; and the plant is run continuously, except on Sundays and regular legal holidays.

BIG GUNS, OFFICERS, CREW, AND MASCOT OF U. S. BATTLESHIP *INDIANA*.

The Gun-Shop

The Factory has grown from two small shops in 1884 to the immense plant, even now much too limited, occupying the major part of the Washington Navy Yard. And it is in the great "gun-shop," so designated, that the greatest interest centers, for it is there that the gun, apart from its mounting, is fabricated from the rough materials, and turned out ready for proof at the Naval Proving Ground at Indian Head. This shop is 130 feet wide and 996 feet long,

and houses under its roof half a thousand busy artisans of a highly trained character. It may be said, in passing, that these men stand entirely upon merit, political influence long since having been barred from interference with the personnel engaged upon so pre-eminently a serious work. The northern end of the shop is given over to the manufacture of the largest of the guns; the middle section, to those of lesser caliber; while the southern part is absorbed in the highly exacting work of making the breech mechanisms. In the gallery over the northern end of the gun-shop, something over 200 men are busy making the sighting instruments—the eyes, as it were—for the guns building below; and each of these several divisions has its own interests and its own peculiar importance.



LATHE TURNING SURFACE OF 12-INCH RIFLE JACKET AFTER SHRINKING.

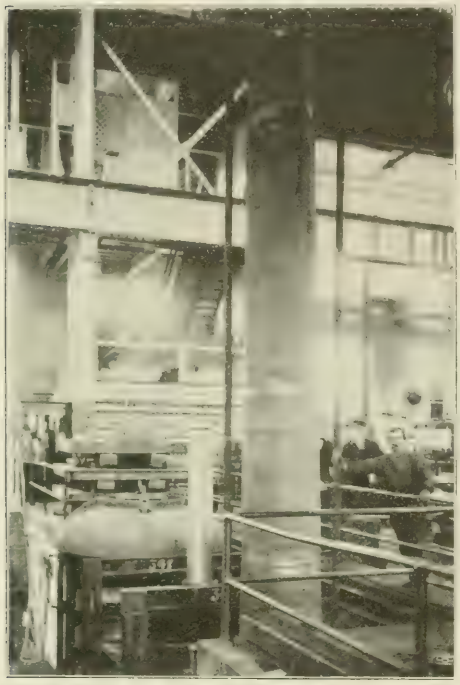
Making a 12-Inch Rifle

Let us follow the course of fabrication of a modern 12-inch rifle—the most powerful naval weapon built for any government. Well may we take pride in the proud position won by American genius and American mechanical skill.

The steel forgings are received at the Naval Gun Factory from several of the great private steel plants of the country. They come in the shape of cylinders of various lengths, roughly bored and roughly planed approximately to the dimensions required for the finished product. Before they have been shipped, however, samples of each have been tested chemically and physically to see that they meet all the requirements set forth in the specifications drawn up by the Bureau of Ordnance. These specifications demand that the tubes, the innermost part of the guns, shall have a high tensile strength (say 85,000 pounds per square inch) so that the jackets—the cover lying immediately next—shall be stronger; and the succeeding covers, or "hoops" as they are called, must be still stronger. The jacket of every gun is shrunk on the tube; and the hoops are shrunk successively over the jacket, until the greatest mass of the steel is concentrated over the breech and the explosive chamber, where the powder is first ignited and develops its maximum pressure. If one take the contour of a naval rifle, using the center-line of the bore as a base, a curve starting from the rear end of that line, rising easily but quickly to the maximum diameter, and thence to the muzzle—not back to the base-line at that end—one would have a fair idea of the pressures developed by the propellant charge. The gun, therefore, is designed to meet these varying pressures with a correspondingly resistant mass of steel; and the weapon is built progressively stronger outward, that the shock may be the better absorbed, and, in case of rupture, that the break may occur within the tube rather than in the restraining jacket or hoops.

The Tube and Jacket

The tube having been placed in one of the great lathes and most carefully centered, its rough surface is patiently cut away until its external diameter is approximately the dimensions of the



THE SHRINKING-PIT.
Raising out the first jacketed tube for a 45-caliber 12-inch rifle.

drawing. The jacket, which, in the case of all guns from the new 5-inch upward, reaches from breech to muzzle, is also put in a corresponding lathe and bored most carefully to the exact dimensions set down on the drawing. As this work progresses, every inch of the bore is most accurately measured by star-gauges that read to the thousandth of an inch. The machinist in charge of the lathe must watch continually the cutter on his boring bar, and see to it that no stray bits of steel shavings jam in between and scratch that finished surface. With the jacket finally bored and ready to be shrunk on the tube, the outside of the tube is then turned down until it is just a few thousandths of an inch greater in diameter than the bore of the jacket — the surface, likewise, being free from all blemishes.

The next stage is that of expanding the jacket by heating, so that it will be large enough to go over the tube. The shrinking-pit where this work is done occupies a central position in the gun-shop; and over it, spanning the width of the main space, are run freely four big electrically-driven cranes — the largest having a lifting capacity of 110 tons. In the pit are two hoop furnaces and one jacket furnace. The heat is produced by petroleum jets; and the hot air—not the flame—is fed into the lower part of the compartment holding the jacket or hoop, as the case may be. The temperature ranges from 600° to 750° Fahrenheit. On the south side of the shrinking-pit are the wells in which the tubes are stood upright.

About thirty hours ago, let us say, the jacket was picked up from its lathe, and carried to the jacket furnace, into which it was lowered vertically; the top of the furnace was sealed, and the petroleum blast turned on to heat the air to be led to the jacket. Coming in from below, and rising naturally, the entire tube is thus uniformly heated within a few degrees of variance. In the meanwhile, the tube has been placed vertically in its well, carefully centered, a cap fitted on top, and streams of cold water circulated within.

Everything is now in readiness. The top of the jacket furnace is lifted and carried away by one of the smaller cranes, while the big 110-ton affair is made ready and secured to the heated jacket. This work is not without its measure of peril, for the men must stand about the open mouth of the furnace and in the dizzying air therefrom. Quickly the 40 feet of jacket is hoisted clear, and swung over near the shrinking-pit. No chances are taken, however, the bore of the jacket is quickly but no less carefully measured by long-handled star-gauges. Everything being right, the big crane brings the jacket directly over the waiting tube; while sweating men, with great asbestos mittens, push the bottom of the jacket fairly into place and guide it over the head of the water-cooled tube. Slowly it is lowered; and, as it moves freely, it is allowed to settle faster, until, in the last dozen feet, it slides down the tube on a run, and lands in place with a stamp that lifts a heavy load from the shoulders

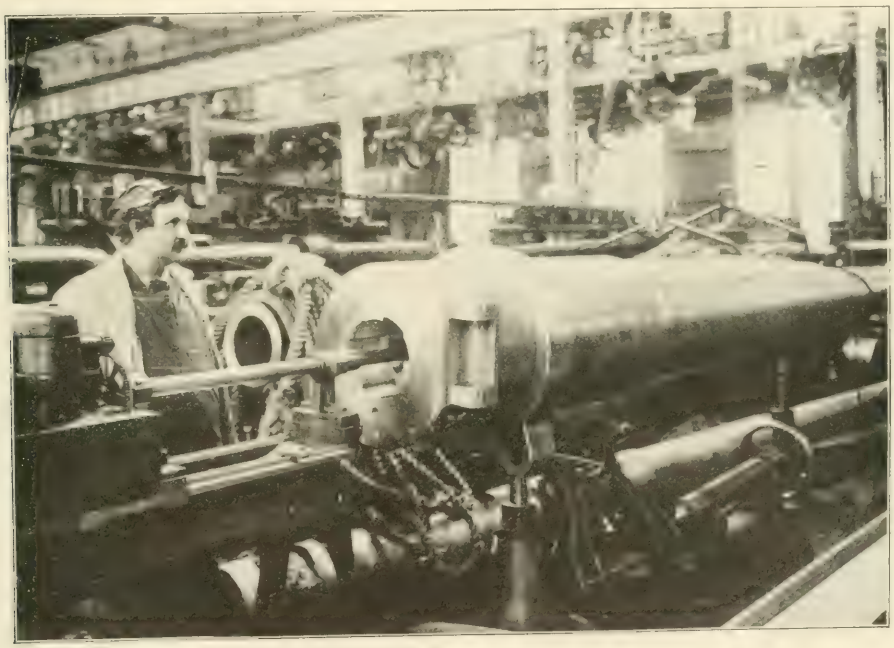
of the superintendent of the shrinking-pit.

Should the jacket be unevenly heated, or should it be canted in lowering, it might stick; and there would be a problem involving thousands of dollars, and, perhaps, the total loss of the jacket. Owing, however, to the skill of long practice and to the many precautions taken, this has happened but rarely. It is much more apt to occur in the smaller guns, in which cases, the mass of metal being less, cooling takes place more rapidly. The water within the tube is still allowed to circulate, and in about twenty-four hours the whole bulk will be cool enough to be withdrawn from the pit.

In shrinking, the jacket is still distended by the few thousandths of an inch difference between its original internal diameter and the greater diameter of the outside of the tube. The pressure of this restrained difference constitutes the grip with which the jacket continues when cold to hold the tube firmly. If this were not the case, heating the gun during continued firing, especially in the lighter calibers, would cause serious loosening.

The Hoops

The hoops, which follow, are heated in the same way. Being smaller, however, they take less time; and, being lighter, many or most of them are put in place with the gun in a horizontal position in the lathe. After the jacket has been shrunk in place, the embryo gun is put back in the lathe, and the work proceeds as before, the first hoop being accurately bored to the dimensions of the drawing, while the external diameter of the jacket, as far as the hoop overlaps it, is afterwards turned to suit the hoop.



IN THE SOUTH GUN-SHOP.
Boring out the powder chamber of a 6-inch gun.

The reason of this is that the operation of boring is a much more delicate one than that of turning the outside. As one can see, the cover in each case prescribes the dimensions of the thing to be covered—the reversal of the practice prevailing generally with other things.

By building a gun thus in sections, it is possible to have a more intimate knowledge of the entire fitness of the material from core to cover; and results are obtained that would otherwise be denied in a single big forging—no matter how carefully worked. Hence the modern "built-up" gun.

Boring and Rifling

With the last hoop in place, the gun is put in the lathe for the last time, and most delicately centered preparatory to the finished boring of the tube. This work must be done with the utmost exactness and exquisite smoothness — the boring bits being adjustable to the most minute part of an inch. With this completed—and it takes weeks and weeks to do the work—there follows the even more delicate task of cutting the rifling threads, by which the projectile is made to revolve laterally and is given that spin which adds to the accuracy of its flight and to the flatness of its trajectory. This

Breech Mechanism of an 8-Inch Rifle.
Dummy to which all breech mechanisms are fitted before issue to service.

rifling is not uniform in its twist; it is progressive — from zero at the powder chamber, to a maximum at the muzzle. It is cut by a very ingenious tool, fashioned with all the cunning and precision of a watchmaker's art, and yet strong enough to bite into the steel. This tool is called a "rifling-head," and it is so arranged that it can cut four of the threads simultaneously. The "rifling-head" is fitted to a long boring bar—which, by the way, is as long as the bore of the gun —and into this bar is cut a groove, rectangular in section, that exactly corresponds with the twist of the rifling of the particular gun in question. Through the last bearing—that is, the one nearest the muzzle of the gun to be rifled—is a fixed bolt or guide-stud, which is set into this groove; and, as the bar is pushed forward, the "rifling-head" is turned accordingly. A strap passing around the rear end of the boring bar and heavily weighted, gives the bar a constant tendency to revolve, and thus keeps the "rifling-head" bearing evenly and continually against the guide-stud. This operation has to be seen to be appreciated. Only the most skillful men are employed at this task, for any failure in the perfect accuracy of smoothness of this cutting would bear directly upon the life of the gun and the precision of its fire. Every inch of this work is measured most delicately. Months are absorbed in the operation; and then the final touches remove the slightest trace of a wire edge or the least bit of unevenness.

The Breech Mechanism

Next to the work of cutting the rifling, comes that of cutting the threads of the interrupted screw which forms the locking shoulders, so to speak, for the breech-plug. This breech-plug, with its contributive parts, is a wonderful affair; and the greatest of mechanical and engineering skill have been devoted to making it the reliable device it is to-day in our high-powered guns. Some notion of the amount of work involved in its construction may be had in remembering, that, of the 52 tons of the modern 12-inch rifle, apart from its mounting, but 1,512 pounds is centered in the breech mechanism; and yet it takes as long a time to build this relatively small part as it does to construct the gun itself—which, in the case of these big rifles, is from eight to nine months. Hand work of an exquisitely fine nature enters extensively into its fabrication. This mechanism contains the firing device, the locking mechanism, the breech-plug, the gas check, and the controlling gear and cranks that turn the plug free, withdraw it, and swing it to one side so that the gun may be reloaded. To make these parts strong enough to withstand the chamber pressure of nearly 17 tons to the square inch, and yet light enough to

IN THE SECONDARY GUN-SHOP.
One of the Navy's Spitfires.

move with celerity, is one of the tasks set the ordnance engineer; and the performance of our guns at target practice, and their endurance under stress, are proof of the skill displayed in their design and their fabrication—for there must be no chance of a leak of these hot, erosive gases under that enormous pressure, for gases, so escaping, would soon cut away disastrously the protecting metal, hard as it is.

It would take a book to tell all there is of interest in the work carried on at the Gun Factory, for the field is a diversified one. To give the guns a proper mounting, is no small part of the problem; and to make the guns in those mounts so mobile that they may follow quickly and accurately a moving target, is the prime difficulty confronting the ordnance engineer in building the controlling mechanisms for big guns. It is claimed, however, that this obstacle has finally been overcome; but how, must not be published. No small part of this mobility and accuracy lies with a proper sighting instrument—one that will withstand the shock of the gun's discharge and continue to give true readings; and this, too, our ordnance experts think they have successfully met.

Sure it is, however, that in workmanship at any rate, our guns stand unrivaled; at Indian Head they have proved their superior might; and at target practice they have made records of which any reasonable foe might well be wary. Fine as all of these performances have been, yet we are promised still mightier engines of destruction upon the present dimensions, by the adoption of nickel steel in the future.

The record of only two decades is a remarkable one, realizing, as we must, that we had to learn the greater part of what is vital to success in this work by actual experience—for our foreign rivals naturally kept the prime things secret. The Naval Gun Factory has set the standard for the private manufacturer; and, even though the day should come when the plant were able to make a smaller percentage of the guns required, its existence and continuance would be prime to the best interests of the Nation and the Navy.

A WORLD OF MIGHTY WATERS.

Very rare, indeed, among the myriad photographs of Niagara, are those which convey as powerful an impression as this, of the dynamics and hydraulics of the peerless cataract. It is well worth while to observe the irresistible plunge of the fall, as depicted by a mass of repeating lines converging at the pictorial point of supreme value—the point of emergence. Observe, also, the strange emphasis which is imparted to the drama of the waters by the grim, immovable mass of Goat Island; the types of permanence and of transition in most eloquent contrast, thus fairly overpower the imagination of the spectator. The picture is a *tour de force.*

Principles of Artistic Photography

Difficulties Encountered by the Novice, and How to Meet Them

Second Paper*

By LOUIS A. LAMB

Editor, *Pit and Post*

IT is assumed that the ambitious novice is provided with a 5-by-7 tripod camera of good bellows capacity, equipped with a symmetrical anastigmat of eight inches' focal length, working at F/6.8 as a doublet, or at half that aperture and with a focal length of sixteen inches as a single landscape objective; that the lens is fitted with a shutter of the "between the lens" class, working in the plane of the diaphragm and adjustable for exposures ranging nominally from one one-hundredth of a second to "time exposures" of any duration. It is assumed, further, that the outfit includes rapid plates.

General Requirements

What general rules or principles govern the proper use of this equipment? Speaking with reference to the merits or demerits of the final result, or the "print," as it is called, it is obvious, First, that the subject must be well chosen—in which specification may be included everything whereby the really dominant idea, concept, or object is assured supremacy in the finished picture; Second, that the impression produced on the mind or on the emotions by the subject must be duly reproduced in the picture. Failing in these points, the result is of uncertain value.

Speaking merely as technical photographers, we may say that the print must reveal:

1. Wise choice of position, considering the limitations of the apparatus and of the environment.

2. Judicious use of the light available.

A SAFE HAVEN.

An example of adroit management of meager materials in a square space.

*NOTE.—The next paper will take up the subject of manipulative work, and especially the development of the exposed plate. The first paper of this series appeared in February.

3. Accurate exposure, recording a correct scale of gradations.

4. Well-advised development, to preserve these tonal qualities and values in the negative, and to transmit them to the final print.

5. Suitable choice of a printing medium.

Surprising as it may seem, the fact is that an observant person will attain complete command of all these matters in a very short time. The essential thing is to have an analytical knowledge of the subject to be represented—its determining characteristics of form, texture, mass, stability, motion, and so on—for there is no possibility of representing correctly that which the mind of the artist has not fully comprehended. First, form a definite concept of the subject; second, compare the printed image with the mental image; third, profit by every failure to make the negative and the mental image coincide. A failure which obviates danger of future failures may be counted a success.

THE YEAR'S LAST SMILE.

We have here an effort to translate into forms and values the mellow light and soothing repose of an autumn day. The tranquillity of the picture, and its obvious serenity of mood, are due entirely to the artifice whereby the photographer obtained the broad sweep of placid water in the foreground, and that whereby the graceful fretwork of limbs and twigs was made to fill the upper part of the space.

Choice of Position

Choice of position depends primarily on the focal length of the lens, the bellows extension available, and the size of the required image. The worker must decide at the outset which of innumerable objects before him he wishes to picture; he must give to each its rank, and adjust everything so that the assigned importance of each object shall be maintained. He must know in advance how much detail he needs in the print; and he must know which, and how many, of the infinite number of perspective planes are to be depicted sharply.

If an object is to be depicted in its true size, it must be placed at a distance from the diaphragm exactly equal to twice the focal length of the objective, and the bellows must be drawn out precisely the same distance. Evidently, therefore, focal length is the vital consideration about an objective, and the controlling factor with reference to position or point of view.

Within limits, however, the photographer's control of the lens diaphragm enables him to overstep the normal restrictions of focus. It is elementary that the power of a lens to produce simultaneously, in a single plane, sharp images of objects at different distances from the cam-

"A STERN AND ROCK-BOUND COAST."

This picture is of rare charm in its original state—platinotype—on account of the remarkable variety of textures and tonalities represented. It commands study, also, for the beautiful disposition of its masses of light and dark. It fully typifies the æsthetic capabilities of the camera, properly used. Note the high significance of the group of repeating lines diagonally across the picture, as the unifying force holding together the balanced masses on the right and left.

era, depends on the relation of focus to aperture and on the numerical value of the focus. The shorter the focal length and the smaller the aperture, the greater the number of planes which may be depicted sharply at the same time. Conversely, the longer the focal length and the more rapid the lens, the fewer the planes it can represent critically sharp at one exposure. On these considerations, mainly, rests the immense importance of the diaphragm; but it has other functions as well—namely, the regulation of exposure and the equalization of illumination over the plane of the image.

Use of "Stops"

One of the chief difficulties besetting the amateur is the proper and efficacious

TREMONT STREET, BOSTON.

A highly satisfactory handling of a "commercial subject." The contrast of nature and urban life gives the view a most pleasing effect.

use of the "stops" or diaphragm of his lens, for its dual purpose of regulating the light or, even more frequently, of governing the "depth of focus" of the objective. It is simple enough to remember that the successive openings of stop F/7.7 or, as usually marked, F/8; four-tenths will be indicated for F/11; and so on. The order of stop numbers, expressed in terms of focal length, is as follows: F/5.6, 6.3, 6.8, 7.7 or 8, 11, 16, 22, 32, 45, 64. As a matter of course,

REST.

Close study of this picture will reveal its charm in its subtle play of concealed curves and opposed straight lines. The chief of these curves may be traced along the boundary between the broad masses of light and shade on the right of the picture, near which line the figure is posed. The subject reveals high artistic sensibility.

the diaphragm vary by a constant ratio of *one to two* in terms of area. Accordingly it will follow from the laws of light, that the exposure must be doubled for each reduction of aperture from number to number of the index. If one tenth of a second is normal with aperture F/6.8, two-tenths will be required with the doubling of focal length due to halving a symmetrical lens makes the full aperture of the single just half that of the whole lens. For example, half of a doublet rated at F/8 will work with a maximum intensity of F/16; and F/11 of the diaphragm ring will mean only F/22 for the single.

With reference to the increase of depth of focus by "stopping down," it is not necessary to tire the beginner with rules when ocular evidence of the clearest sort may be found on the ground glass. The proper way to gain the knowledge requisite for the use of stops to bring diffused images into sharp focus, is to make careful mental note of the changes observed on the screen as the diaphragm is moved from one number to another. A single test will fix the matter firmly in mind without resort to rules.

THE LAST BEND OF THE ROAD.

We have here one of the charming and persuasive bits so commonly seen and so seldom well photographed. The reason is that camera workers often neglect to study the essential elements of what appeals to them as beautiful. In this picture, it is clear that the merit of the piece lies in the clever handling of the *nouveau art* curve of the road joining that which defines the form of the large tree in the center. The placing of darks and lights, also, is good.

Timing Exposure

Correct timing is one thing which must be learned in the school of experience. The practiced worker can tell to a nicety, by inspection of the ground glass, just what exposure his plate needs. The beginner ought to learn this for himself by giving a number of plates a regular series of exposures on the same view under identical conditions of lighting, and with the same stop. For instance, let him focus sharply on a distant landscape with the lens wide open, and give to successive plates exposures varying as 1 to 2. If careful note is made of the appearance of the image in each case, and if the numbers 1, 2, 3, etc., are marked on the film side of the plates before development, to insure proper identification when dry, mere inspection of the final negatives will tell which exposure was best, considering the development and in view of the needs of the worker. It may as well be said, in passing, that the "latitude" of modern dry plates is most liberal. By this we mean that exposures considerably under or over the normal timing will yield tolerable results under modern scientific development. Of this, however, we shall have occasion to speak in some detail further on.

As a useful hint to the unpracticed novice, the following easily learned table will be useful, pending the acquisition of such ripe experience as will make it *de trop*. It is adapted from the excellent table of Dr. J. A. Scott:

Units of Exposure Required at Noon	
June, July, and August	1
April and May	1¼
March and September	1½
February and October	2
January and November	3½
December	4 to 5

State of Weather	
Sunshine	1
Sun veiled lightly	2
Heavy clouds	3
Stormy	4 to 6

Situations	
Open sky and water	1
Distance	2
Middle Distance	3 to 4
Immediate foregrounds, according to aspect	8 to 32

No prescription can be expected to replace common sense and judgment; but the approximations of the table will be useful guides to the perplexed beginner. He may modify the values for himself as his data pile up and as his memory grows keener. The latitude of almost all plates is sufficient to compensate errors within reasonable limits. But *do not under-expose*. It is fatal.

Composition

The arrangement or "composition" of a picture is the subject of endless discussion; but it is almost wholly a temperamental matter. The man who can compose unerringly is an artist, whose skill is the resultant of forces far antedating rules and schools. However, even here, there are certain principles which will assist the worker on his hard way toward

IVORY AND FINE LACE.

This snow scene, though open to criticism for its meager tonal range, merits careful analysis by those who care for purely decorative effects. It fairly "out-Japan's Japan" in this quality.

the goal of every artist's ideal—which is, and always will be, consummate arrangement of lines, masses, values, tones, planes, and all the rest of the elements of design.

What Makes a Masterpiece?

In a picture of such quality as to be acclaimed a masterpiece, certain constant factors are discoverable. We find that there is an unequivocal unity about all great work. Though its parts be myriad, they have jointly and severally an imperative relation to a dominant, absorbing, and irresistible central idea. Everything in the picture points to it, or suggests it, or echoes it: it is the focus in which all the energies of the picture converge. The lights and shades, the lines and masses, the tones and values of the whole, are adjusted in such a way as to coerce the eye and mind to rest on, and to compass, the master theme. There is no possibility of escaping the artist's intention; he has ordered everything so that the beholder cannot stray beyond the frame; so that no question can arise which the canvas or the print will not answer categorically and fully for the man of culture and acumen. In fine, everything useless is eliminated, and everything worthy of retention is employed to exalt the supreme concept.

Work of this kind, whether photographic or other, is justly entitled to classification among the "fine arts;" and there is no valid reason why the camera should not be a most valuable instrument of the highest art.

It is forbidden, except for a distinct purpose, to place the principal object in the geometrical center of the space—for the reason that such position suggests radial lines diverging to infinity, thus depriving the principal object of its rightful dominance. The center is the position of

quiescence, not of action; of weakness instead of strength. Assign to your chief object a place in one of the quarters of the space; and so connect together all the points of interest that the eye will be led naturally throughout the picture and will be brought to rest on that which has the highest claim to attention.

Much has been written about the proper forms and boundaries of a picture; but a moment's reflection will suggest mural decorations of all forms, and all equally meritorious—spandrels, lunettes, ellipses, ovals, circles, foliations, triangles, and mere ribbons or narrow panels, not to try to catalogue the endless variety of irregular spaces that occur in architectural designing. Each space calls for special treatment, but the principles in all cases are the same.

The photographer is not barred from any field of composition he may elect to enter—from the simplest of decorative designing to the most elaborate historical subjects; but if he expects to attain eminence, he must conform to the laws of unity, coherence, co-ordination, and harmony, by which all artists are governed. More than all else, he must be possessed of a worthy idea and endowed with that rich imaginative faculty which alone can give vitality to a graphic idea.

Specific Rules

Avoid centering your principal object on the plate.

Chain together the related parts of the picture, and avoid detachment and scattering of your pictorial elements. Keep the lights connected and the darks coherent, making two series of values consistent throughout the scale or key chosen for the work.

Remember that the lights and darks of a picture must be in equilibrium, and that a small mass of deep black will counterbalance a large expanse of white.

Preserve the extremes of your gamut—the deepest blacks and the pure white—and employ them in nice opposition, to gain supreme effects.

Avoid right lines where you can employ curves; and do not suggest that the skeleton of your picture is made up of

THE FINGER OF THE LAND STRETCHED OUT TO THE SEA.

Pleasing as parts of this picture are, it is plain that it would be helped by brave pruning and trimming. There are at least two agreeable pictures in it—as the dotted line will suggest. It is a helpful exercise to try all the permutations of the subject before actually trimming down the print.

straight lines if you can intimate that the basic lines are curved. So arrange your principal masses that the eye will perforce traverse curvilinear paths in compassing the subject.

Avoid repetition of lines, masses, contours, tonalities, and values, except in positions of great importance. The artifice of repetition is one of the most powerful organs of graphic art, and it should be reserved for the climax, not frittered away in trivial situations.

If you wish to intensify the effect of a curve, remember that it may be done by the use of a rigid straight line as a foil. Conversely, where a straight line is needed to give a sense of strength, the effect may be heightened by clever juxtaposition of a suitable curve. Use right lines sparingly in arrangements.

Keep the center of gravity of your picture low enough to suggest stability, unless your object is to express the contrary state of things—instability.

Do not let the principal object seem to be leaving the picture, except as a clever and effective device to express an idea of transition, in which case it becomes one of the potent agencies of dramatic artistry. In general, save your points of entry and emergence, as you do your deepest blacks and your straight lines, to give emphasis or significance to your symbols.

Detail and Sharpness

The question of detail and sharpness is perennially discussed among photographers without much profit. The safe rule seems to be that the picture should be critically sharp, if possible without prejudice to the idea sought to be conveyed. In the rendering of a head, it is worse than folly to labor and stop down the lens for the sake of obtaining sharpness of definition, which is neither essential to the record nor pleasing to the æsthetic sense. Flesh is plastic, mobile, and vital; to represent it as one would iron or marble, is utterly false and atrocious. The flesh is made up of fibers and cells, and the skin has pores; but these things are of interest to histologists and anatomists, not to artists. It is well to manage your lens in such a way as to avoid critical detail in all portrait work —at least in all that professes to be of the "advanced" genre.

Even in the most purely technical work, universal detail is a defect rather than a merit, though specific detail is highly essential. For example, if you are trying to make a picture of a car truck, you will want everything about it keen and sharp. The purpose of the picture, however, will in no wise be enhanced, if, by excessive stopping down, the trees in the distance are rendered equally well, thus compelling the eye of the observer to wander from that which is essential in the picture to a mass of irrelevancy.

THE RACE FOR FORTUNE.
As an example of the realistic genre, this picture is interesting. The formal, vertical arrangement is modified effectively by the repetition of the crystal globes, reflecting each its crescent of light and affording a pleasing "horizontal component" as a foil for the vertical lines.

It is well to remember that there is no device more efficacious in arresting attention than a clearly localized area of sharpness; hence the use of detail must be made a study, just as we try to reduce the tonal gamut to a science. The eye will pass over indistinct images, and will

ENCHANTMENT.

The merit of this picture is almost exclusively bound up in the mediæval richness of its tonal gamut. The disposition and grouping of the objects will repay attention, though not of prime importance in the scheme.

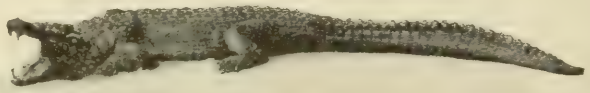
rest on the minutest area of critical sharpness; therefore, be careful that the sharpness coincides with the essential, not with the trivial.

The camera-maker makes provision for the needs of the worker in this respect by means of rising and falling lens boards, by vertical and horizontal swings, and by elongation of the bellows. The lens-maker, too, in furnishing iris diaphragms, gives the photographer great control over the distribution of sharp definition. Care is required in the use of all these adjustments; but, within the limits of allowable distortion, they afford means of pictorial grace which no worker should—though most do—ignore.

Finally, the utmost ingenuity and imagination are required in the proper marshaling of symbols and analogues, whereby the purpose of a picture is made unmistakable to all who see it.

These hints cover the principal points which should be remembered by the camera worker in arranging his picture. If they are fully obeyed, and are coupled with proper technical skill on the part of the worker, they will yield satisfactory and meritorious photographs in every department of the craft.

(To be continued)



A Path

HE sought the whither of all life for long,
And drifted on an aimless, treacherous main;
Hopeless at last, he turned to labor's song,
When lo! across the deeps a way was plain.
—Margaret Prescott Montague in *Lippincott's.*

Flaws in Castings

Their Prevention by Means of Thermite

By DR. ALFRED GRADENWITZ
Berlin Correspondent of The Technical World

THERMITE, which is mainly a mixture of finely divided aluminium and iron oxide, is known to go on burning spontaneously after it has been ignited at any point. This fact has been utilized by Dr. Goldschmidt in connection with a number of further discoveries and inventions constituting the body of quite a novel branch of chemical science to which the name *Alumino-thermics* has been given.

In its spontaneous combustion, thermite produces temperatures as high as about 3,000° C. The iron is thus liberated in a pure state, free from carbon, a slag of aluminium oxide (the so-called artificial corundum) being formed at the same time. The use of thermite for obtaining castings free from pores and flaws is based on the fact that the material is able to burn without requiring any supply of gases, and without giving rise to the formation of any gaseous products in the reaction. The idea was originally suggested by Mr. W. Mathesius.

The action of thermite on metallic baths is a triple one:—In the first place, the metals produced by the reaction are alloyed to the bath; second, the heat of reaction of the thermite is transmitted to the bath; and third, in the case of a suitable application, a lively intermixing of the metallic bath will take place.

The thermite is introduced into the liquid metal in a sheet-metal box, so as to produce the reaction below the surface of the fused metal. In the case of cast iron, titanium thermite is used, which is a thermite containing, in addition to aluminium and iron oxide, some titanium oxide intended to supply to the fused metal a certain amount of titanium, when any one of the three effects pointed out above will be produced.

A box filled with titanium thermite (Fig. 1) is fixed by a wire to an iron bar, the latter being fitted into a centrical hole in the box. The bar used in this connection should be fairly free from rust and perfectly dry. After the box and the bar have been reheated to the temperature of the hand, they are thrown into the metallic bath by a workman whose hands are protected by gloves against the radiating heat from the surface of the fused metal. During the reaction, the bar is kept within the metal as motionless as possible. After the thermite box has been dipped into the bath, the reaction will take place instantaneously, lasting about 1 to 1½ minutes in regular course; it is manifested externally by a lively bubbling of the bath, resulting in a mixture so intimate that it would be impossible by the use of any other agent. This intermixing is, of course, attended with a material improvement of the iron

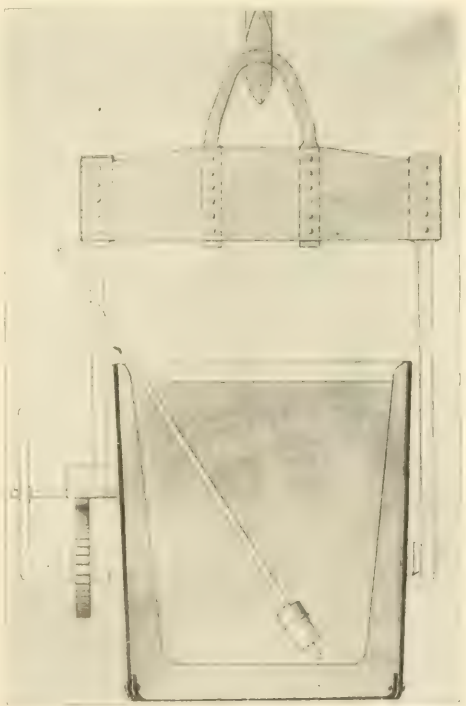
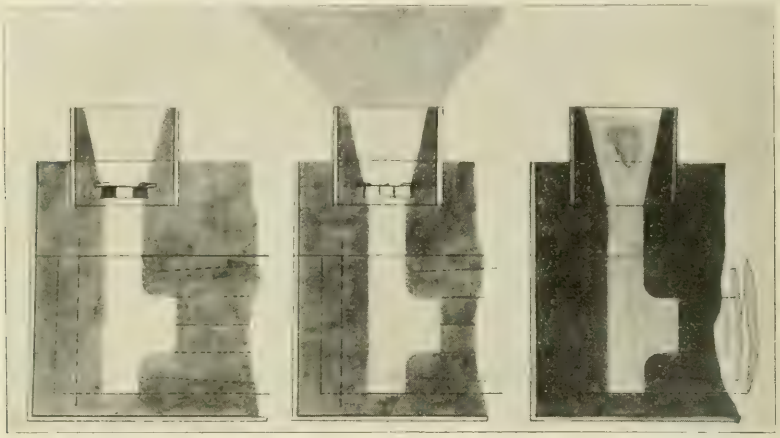


Fig. 1 Casting-Pan with Titanium Thermite Box Inserted.

itself, any differences due to the variations in the iron from different stages melted together being compensated for. The iron expert will notice at once in the liquid metal, the influence exerted on its condition by the thermite reaction. In fact, the jet flowing from the cupola furnace onto a pan is perfectly opaque; Metal surfaces that formerly would spit continuously, become quite motionless after the reaction has been produced.

A further property of titanium is the fact that it will fix nitrogen. In the case of the liquid iron containing even small amounts of titanium, the latter will decompose the atmospheric air, fixing the



(*a*) (*b*) (*c*)

FIG. 2. USE OF FLAW-THERMITE IN MAKING STEEL CASTINGS.
(*a*) Before, (*b*) during, (*c*) after casting process.

while in the case of the iron undergoing the thermite reaction, the jet issuing from the pan has a clear, translucid appearance. The effect may be noticed also from the aspect of the breaking surfaces of iron treated with thermite; in fact, the grains of the iron are much finer, its structure is rather dense, and the iron has a remarkable polishing capacity, any disturbing graphite films becoming so small as not to be noticed by the naked eye. In the case of the amount of thermite being sufficient, the increase in temperature produced by the reaction is materially higher than a simultaneous unavoidable loss by heat radiation; this increase, as well as the reduction of the ferro-oxides dissolved in the bath, will materially augment the liquidity of the molten metal. Finally, the cast iron will receive a certain addition of titanium from the reaction.

Mr. Mathesius does not think it safe to state whether the addition of titanium or the mechanical effect of the reaction is mainly operative in freeing the cast iron from the gases dissolved. It is, however, a fact that the castings are freed from any gas they may contain. nitrogen it contains; while the oxygen is made to form a compound with iron, which is dissolved in the liquid metal without necessitating any further reaction. This accounts for the perfect absence of pores in cast iron treated with thermite. The effect of thermite on larger steel castings, in preventing the formation of flaws, is quite analogous. The thermite used to this effect is a special kind known as "flaw-thermite," which is made to act only during the casting process.

In the steel foundry, the formation of flaws underneath the rising funnel is known to be a serious drawback. The steel rising from the interior of the casting into the rising funnels had to traverse the whole of the mould, giving off on its way a large portion of its own heat to the colder walls of the mould. Even in the case of the cross-section of the funnel being very great, the steel filling the latter would therefore in many cases be solidified more rapidly than the steel in the interior of the casting, thus preventing any metal from the funnel returning to the interior of the steel casting to fill up any hollow formed during the solidi-

fication. This would result in flaws being formed in most cases immediately beneath the rising funnel.

Instead of the thermite welding process used in many foundries to fill up these flaws, Mr. Mathesius thinks it is much more practicable so to control the solidifying process of steel castings by the use of thermite, as to *prevent the formation of flaws*. Fig. 2 shows a simple way of effecting this. On the left of the figure, is shown a portion of a steel casting mould, into the rising funnel of which a box containing thermite has been fitted before the casting process. The steel rising from the mould into the funnel will traverse the central hole of the thermite box, igniting the contents of the latter. As will be seen from the middle part of the figure, the thermite is burned while the steel fills up the funnel, *i. e.*, beneath the surface of the liquid metal, thus driving the whole of the contents to an extremely high temperature. The steel in the funnel, therefore, remains in a liquid condition for a longer period than the one within the casting. As shown in the third part of the figure (*c*), any flaws will now be formed at a place where they are quite harmless—namely, in the interior of the rising funnel.

Another use of thermite in boxes is illustrated by Figs. 3, 4, and 5, where the manufacture of forgings free from flaws is illustrated. In Fig. 3 is represented the cross-section of a forging block made after the ordinary process. As will be seen, the flaws are developed greatly, reaching 42 per cent of the depth of the block. If a box of thermite be introduced into the block (see Fig. 4) at so late a moment as to allow of the steel throughout the block passing to a plastic condition, the thermite reaction is started instantaneously, when the mass of the block is again liquefied throughout; and, the steel filling up any flaws already formed, a funnel of different size, opened upwards, will be formed. The latter should be filled up with liquid steel kept ready for the purpose, whereupon, the thermite slag rising to the surface, a practically perfectly dense block having only small flaws at most on the upper edge will be formed, as shown in Fig. 5. Steel blocks of enormous weight have thus been manufactured free from flaws.

FIG. 3. TEN-TON BLOCK OF STEEL, CAST WITHOUT USE OF THERMITE, SHOWING SERIOUS FLAWS.

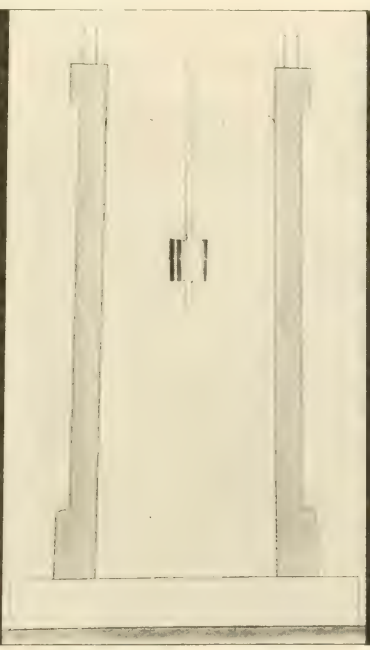


FIG. 4. DIAGRAM TO ILLUSTRATE THERMITE PROCESS OF PREVENTING FLAWS IN CASTINGS.

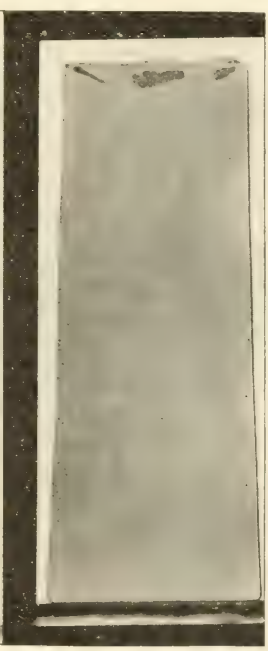


FIG. 5. TEN-TON BLOCK OF STEEL.—FLAWS REDUCED TO MINIMUM BY USE OF THERMITE IN CASTING.

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Illustrated articles on topics of timely interest are solicited for publication. Those that are *short* and *accompanied with good photographs* will receive special attention. Accepted articles will be paid for at regular space rates.

¶ Character is the only true culture.

¶ Good cheer is half of good courage.

¶ Do something, and do that something well.

¶ When a man has fame he does not know it.

¶ Success mixture—Muscle and hustle, brains and method.

¶ Running in old ruts may be more risky than blazing new trails.

¶ An angry word, like a letter dropped into the post, is a difficult thing to recall.

¶ A man's ascent amongst the living counts for more than his descent from the dead.

¶ The new arithmetic——Farmer + brains, knowledge, strength, industry, and economy ÷ wisdom — stinginess = home comforts.

¶ All the great work in the world is simply doing the best that is in us.

¶ There is no virtue in the one-day sprint that requires the six-day snooze.

¶ He is always a poor man who knows no more in life than making money.

¶ The first step toward curing a crooked world will be to straighten your own glasses.

¶ The secret of all great undertakings is hard work and self-reliance. Given these two qualities and a residence in the United States of America, a young man has nothing else to ask for.

Wireless Telephony

ELSEWHERE in this issue will be found a description of the various wireless telephone systems which have been proposed, together with a brief history of the general subject, by A. Frederick Collins. The first suggestion of a wireless system was by A. G. Bell in 1880. Professor Bell conceived the idea —after the discovery of the variation in resistance of the selenium cell according to the variation in light thrown upon it— that this principle might be used to reproduce spoken words, and such proved to be the case. The speaking arc is another very interesting experiment described; but, as both of these methods depend upon an uninterrupted visual line and more or less accurate alignment of apparatus, it is hardly possible that they can attain much practical importance or be operated over very great distances. In a recent article Mr. Tesla states that "within a few years a simple and inexpensive device, readily carried about, will enable one to receive on land or sea the principal news, to hear a speech, a lecture, a song, or play of a musical instrument conveyed from any other region of the globe." Aside, however, from this prophecy, wireless telephony offers an interesting field for research and experiment, although after 25 years much still remains to be done to place it on a sound commercial footing.

One More on the Mosquito

TECHNICAL foresight and mechanical skill have scored one more; and the vast New Jersey marshes, home of the mosquito and refuge of malaria, are to become valuable. This has come about through the invention of a machine which makes binding twine, coarse matting, and other things, out of marsh grass. On these marshes grow countless tons of this material, hitherto not considered worth cutting, but now to be worth several dollars a ton. Karl Wessel, a graduate of German technical schools, and a resident of St. Paul, is the inventor; and his machines will be put into operation next summer in a New Jersey factory capable of handling 50,000 tons. This grass grows all up and down the Atlantic coast from New Brunswick to Florida, and the machine makes it all available for use. At $4.00 per ton, the grass will make the marshes valuable, and in many cases will probably lead to their being drained and reclaimed. This will be good fortune for everybody but the mosquito, who doesn't seem to have much luck nowadays anyway. The steady mowing of the marshes year after year, and the draining and reclaiming of them which will likely follow, will be one more step toward his extinction.

American Railway Enterprises in China

AMERICAN railway enterprises in China are in something of a state of dormancy pending the outcome of the Japanese-Russian war. The projected line from Canton on the south to Peking on the north, a distance of 1,400 miles, is probably the most important railway enterprise in the empire. The northern half of this line, from Peking to Hankow, is being built by a company, nominally Belgian, but actually understood to be controlled by Frenchmen and Russians; and of this, about 500 miles is already open for traffic. The southern half—Han-kow to Canton—is, or rather was, under process of construction by an American syndicate; but Belgians, who again are said to represent Frenchmen and Russians, now hold the great majority of shares in the American company.

About a year ago, after much internal disagreement, work was stopped entirely on the Canton—Han-kow line, and since then there has been much diplomatic negotiation between Peking, Washington, Brussels, and London as to the status of the road. Not long ago it was reported that an arrangement was made by which the Belgian shares would pass back into American hands. If this is the case, the road may finally become an American enterprise after all.

Railroad enterprises are commonly looked upon as the opening wedges to territorial ascendancy; and if Frenchmen and Russians, under cover of the Belgian franchise, gain control of the great north and south road, and Russia should prove victorious over Japan in the present struggle, it is not hard to foresee a time when France and Russia will have a great deal more to say about the future of the provinces through which the road passes than Great Britain, or, for that matter, the United States would like.

When the franchises were granted, China had her eyes fully open to the situation. She thought that the Belgians were acting in good faith when, in 1897, they secured the right to build the northern half of the road; but she later learned her mistake, and for that reason she refused the Belgians the southern concession. It appears, however, that through the collusion of a corrupt official, Sheng, Director-General of the Chinese Railways, the American syndicate was given the concession, even though much of its stock was already in Belgian hands. Americans were preferred by Chang Chi-Tung and other high Chinese officials, because they seemed least apt of all nationalities to enter upon a land-grabbing campaign.

Development of the Gas Engine

ONE of the most important as well as interesting problems confronting the engineer to-day is the development of the gas engine, especially types of large size

for power station work. The economy of gas and other internal-combustion engines over the steam engine has long been appreciated; but, until within the last four or five years, little was done with gas engines of large size, owing to the difficulty of regulation and other troubles which were considered inherent in this type of prime mover.

A series of tests were made recently upon a gas engine and a steam engine in an electric lighting station, the two engines being of the same capacity and operating under exactly similar conditions. The economy of the gas engine in this case was very marked, being 45 per cent greater than that of the steam engine.

Among the advantages of the gas engine are its small coal consumption; higher efficiency at small loads; the opportunity for storing the gas when the engine is shut down, thus avoiding all thermal losses; and the use of the cooling water for the cylinder for heating.

A somewhat unique gas-engine plant is at present being installed at Jamestown, N. Y., the power for which will be supplied by natural gas. The initial equipment consists of two 500-H. P. engines of the horizontal single-crank double-acting type. This company began experimenting with the use of gas engines three years ago; and they have operated with sufficient success to warrant the exclusive adoption of gas engines for the entire plant. Several of the largest engine builders in this country are now producing gas engines which are guaranteed to regulate closely enough for the operation of alternating-current machines running in parallel; and this is probably the most exacting service, as far as regulation is concerned, which any engine is called upon to perform. As an economy of 50 per cent is practicable by using the gas directly in the engine instead of under the boilers, the field of the gas engine is a very promising one.

Single-Phase Electric Railway Systems

THE efforts of electrical engineers to cover the field of long-distance railways having heavy train service, appear, from advances made within the past year, in a fair way to achieve success, owing to the development of single-phase alternating-current series motors. Up to within a comparatively few months, electric traction has been dependent solely upon direct-current motors, and a standard voltage of from 500 to 600 is generally considered as high as safety will permit.

In many cases interurban trolley lines cover distances of 50 to 100 miles, and even more; but for these long roads the main power stations develop alternating current at pressures reaching 30,000 volts, and these high-tension currents are transmitted over comparatively small wires with very little loss in pressure to substations located at intervals along the road. In these substations the high-tension alternating current is transformed to direct current of about 500 volts, which is fed into the overhead trolley lines or third rails, for use on the car motors.

While this method of current distribution can be profitably applied in the case of interurban roads where the cars are small and as a rule operate singly instead of in trains, the first cost of such construction for a railroad operating heavy trains at very infrequent intervals —say only three or four a day—would be prohibitive. These substations must be placed about 15 miles apart, and they contain the machinery which must be cared for by competent and high-priced attendants; moreover, the amount of current required for a heavy train would necessitate an excessive amount of copper for distributing the direct current from the substations. Thus the present standard system could never be considered for heavy long-distance railroad work, merely on account of its prohibitive first cost.

Within a year, however, two very similar systems of electric traction have been devised, which will entirely avoid the use of direct current, and will utilize alternating current both for distribution along the line and for use on the motors propelling the trains. While but one alternating-current road has as yet been put into operation, the systems have been sufficiently tested in an experimental way to leave no doubt as to their ultimate

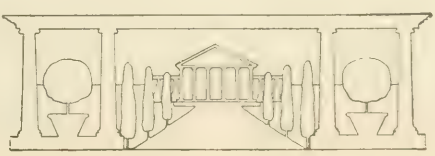
success; in fact, the efficiency of these systems has been proved to be but little inferior to that of the standard direct-current system, and the first cost of equipping a road with alternating current is very materially less than with direct current. The substations of the direct-current road are replaced by transformer stations in the alternating system; and the latter contain no moving machinery and do not require the presence of an attendant. The trolley line, in the case of an alternating-current system, may carry almost any voltage desired, and this can be reduced to any safe working pressure by means of a transformer carried on the locomotive.

The details of the single-phase system have not yet been worked out for heavy service, although a number of interurban lines equipped with this system are now nearly completed. The two most objectionable features of the direct-current system for heavy railroad work—namely, the rotary converter substations and the heavy copper conductors, have been eliminated in the singie-phase system, and the application of the latter to long-distance heavy railroads does not involve any very difficult problems.

Another Cotton-Picker

A NEW cotton-picker has appeared in the South. The only real cotton-picker in the South has thus far been the darky. He has done the work for nearly two centuries with more or less satisfaction and at a varying expense, depending upon the individual characteristics of a not too reliable character. For years a mechanical instrument that would take the place of the darky and do his work with more rapidity and less mental suffering on the part of the overseer, has been the dream of inventors. Such machines have been reported as successful, and when exhibited in Northern cities have seemed to work to a charm. They have drawn cotton from heaps on the floor, and ripe cotton from bolls held to them, with accuracy and dispatch—also money from the pockets of would-be stockholders. But when taken to the fields and put to work, they have always been found to have a colored gentleman concealed in their wood pile. Either they have failed to gather the real fiber from the plants, or else they have picked ripe cotton and green, leaves, stems, and near-by weeds in a wild and wasteful confusion. In no instance have they been found to be satisfactory to either the cotton planter or the too credulous stock subscriber; and the darky has stepped into their wasteful tracks and gone on with his hereditary occupation. The new machine is called the Auto Cotton-Picker; and its inventor, who also invented the round cotton bale, claims that when it is perfected, which has not as yet quite happened, it will divide the cost of cotton picking by five. A recent trial in Louisiana has attracted attention from cotton growers all over the South.

The machine is run by a gasoline engine, and five negro boys operate it, each moving one of its five long arms. These become automatic only when they actually touch the boll. The boy must see to that, but in the trial the machine picked an average of 126 bolls a minute. This is at the rate of 3,000 lbs. of seed cotton per day per machine. The machine straddles one row, which it picks clean and also half of a row on each side. It is not strictly an automatic machine, but merely a labor-saving device, and as such there is much in its favor. It is greatly hoped that this machine will prove a success. If it does, it will not only fill a long-felt want, but will stand out as a bright oasis in a dark desert of previous and unfortunate failure.



WHERE HISTORY

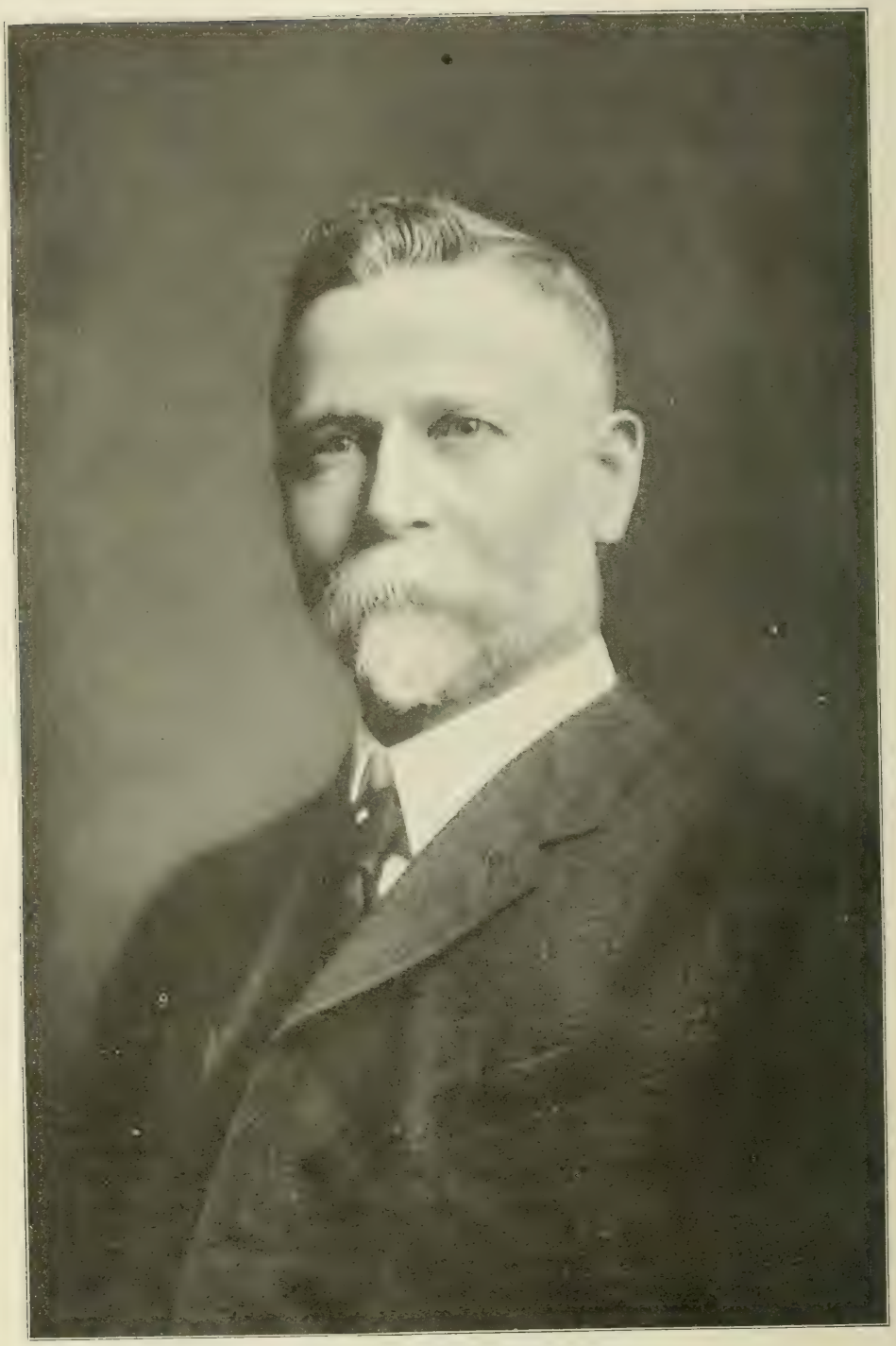
Munroe Tavern, built in 1695, and still standing in Lexington. This house was Earl Percy's headquarters, April 19, 1775. Also George Washington's headquarters when on his last tour of New England, in 1789. Earl Percy was commander of the reinforcements, who, with two field pieces, made a start from Boston about 9 A. M. on the day of the Battle of Lexington, and whose retreat from Concord is a matter of history.

Old Royal House, Medford, Mass. This house was built by Gov. Usher. In 1733, Col. Royal, Sr., a wealthy colonist, purchased and improved it. Sometimes called the "Royal Tavern." Many improvements were made during 1737 and 1738, including an addition to the house, and spacious slave quarters to accommodate the 27 slaves who were the property of Col. Royal. The cellar was termed "The Dungeon." Nearly all the dignitaries who came to the New England colony were entertained here. At the first report of the Lexington battle, Col. Royal fled to Halifax; and this estate, as the property of a Tory, became for a time a possession of the Colonial Government.

WAS MADE

Hancock-Clarke House, Lexington, Mass. Built in 1693. The home of two distinguished clergymen, Rev. John Hancock, second minister of the town, and Rev. Jonas Clarke, his successor. In this house were born Mr. Hancock's three sons and two daughters. The eldest son followed his father's profession, and settled in Quincy, where his son John, of Revolutionary fame, was born. Rev. Jonas Clarke lived in this house from 1760 to the time of his death in 1805. The night before the Battle of Lexington, John Hancock and Samuel Adams, who were in danger of being seized by Gen. Gage if they returned to Boston, slept here, and were roused by Paul Revere on his famous midnight ride.

Slave Quarters of the Old Royal House, Medford Mass., shown on the opposite page. These quarters are the last standing relic of slavery in the Bay State.



C. E. GRUNSKY, OF CALIFORNIA.
Member of the Isthmian Canal Commission.

Panama Canal Progress

Work of the Present Canal Commission Outlined to Date Substance of an Address by Commissioner C. E. Grunsky, January 11, 1905

AT a meeting of the District of Columbia members of the American Society of Civil Engineers, held at Washington, January 11, Commissioner C. E. Grunsky, of California, a member of the Isthmian Canal Commission, read a comprehensive paper outlining the work accomplished by the present Canal Commission since the taking over by the American Government of the canal project.

Mr. Grunsky explained the enormous amount of preliminary work necessary in such an undertaking before it is possible to consider beginning any work of actual canal construction upon a large scale. While the last Canal Commission, he said, recommended the purchase of the French property on the basis of the demonstrated feasibility of canal construction along certain stated lines—at an estimated cost of $145,000,000—this did not relieve the present Commission from considering every phase of the engineering and construction questions over the Panama route. While this estimate was based on an elevation, at the highest point of the canal, of some 80 odd feet above sea-level, it was the duty of the Commission to proceed at once to determine the relative merits of a 60-foot altitude, and, if of a 60-foot altitude plan, of other heights also, and even of a sea-level construction. In other words, the Commission has been proceeding on the basis of making the most exhaustive surveys and investigations, regardless of the preliminary and necessarily hasty surveys of the last American Canal Commission, or of any work or surveys of the French engineers—employing these data, however, of course, where useful.

"While some of the estimates and figures of the French engineers have proven helpful, it must be remembered," said Mr. Grunsky, "that, whereas the French Company contemplated a canal 100 feet wide on the bottom, allowing for the passage of vessels of 29 feet draft, and constructed with a view to producing revenue to the stockholders as a private investment, the American program has no investment feature in the sense of a revenue to be paid stockholders. The canal, moreover, is to be 150 feet wide on the bottom, with a depth of 35 feet of water. It is evident, therefore, that all our work—preliminary investigations, surveys, and actual construction—is that of a new project."

Mr. Grunsky's history of the work of the Commission was in effect a vigorous reply to the public newspaper criticism of the inactivity of the Panama Canal Commission. In the preliminary work of house building and hospital building for the vast army of workers who are to come in; in the organization of sanitation methods, hospital forces, etc.—work necessary in any event, whatever engineering decision may be reached as to the method or route of canal construction—much progress, he said, had been made, and things were fast assuming satisfactory conditions.

Combating the general idea that the Isthmus is a plague-stricken *terra incognita*, where the stranger or visitor is likely to be stricken down at any moment by something vague and terrible, he knows not what, Mr. Grunsky said that the conditions were no different from, and no worse than, those prevailing in other parts of the world where the geography and climate were similar. He believed that the conditions of sanitation and health would be worked out entirely satisfactorily. On this work of sanitation alone, the first year would see about a million dollars expended, with a subsequent annual expenditure, after the system is inaugurated, of probably $800,000.

New Type of "L" Car

The "Easy Access" Car, a Recent Contribution to the Rapid-Transit Problem—Successfully Operated by the Boston Elevated Railway

By WINTHROP PACKARD

THERE has been put into operation this fall on the Boston Elevated Railway a new type of car which is expected to do much in promoting rapid transit. It is nothing more nor less than a car without a platform, the doors for entrance being set in the side of the body at the very ends, instead of in the ends themselves, and being opened and closed by compressed air. A somewhat similar coach has been adopted for use in the new subway in New York; but there, the doors are moved back and forth by the sheer muscular strength of the trainmen, who control them by levers, with the result that complaints have already been made that they do not work satisfactorily.

The greatest difficulty in getting rapid transit is, of course, in loading and unloading trains quickly and safely. Some relief was found in the Boston system by adopting at the start a car with a side door, through which passengers could leave while others were entering by the end doors. There was still trouble, however, from the crowding about the car platforms, and from the swinging iron gates that enclosed them, which easily became blocked so that it was impossible to move them one way or the other until passengers could be made to step aside. Absolute safety requires that these gates shall be shut before the signal to start is given, and the consequent delay in rush hours is considerable.

To the delay caused by opening and closing the platform gates, was added that which came from the necessity of all passengers who entered a car passing through a rather narrow doorway after they had once stepped onto the car platform, and being obliged to turn a right angle in order to do it. In casting about for means to quicken its service, the Boston Elevated Railroad Company devised a coach built out at either end so as to add to its inside capacity the space formerly sacrificed to the platforms.

This new type, called the "easy access" car, looks not very different from the old-type car when the vestibule is closed.

EASY ACCESS CAR.—THE CAR WITHOUT A PLATFORM.

A new type of car in use on the Boston Elevated Railway.—The space ordinarily occupied by a platform at each end, is here entirely within the body of the car, giving direct access in and out. The substitution of sliding doors opening directly into the car, for swinging iron gates enclosing an outside platform, does much to quicken the movement of passengers.

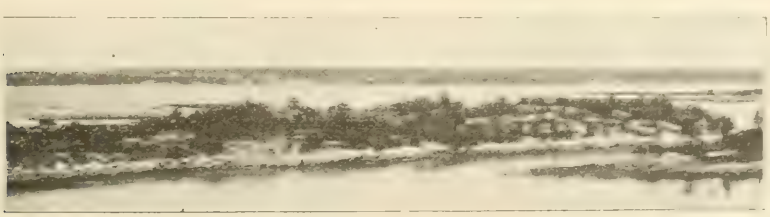
The sliding doors at either end of the sides simply open directly into the seating and standing space; and the rush-hour crowd has the whole width of the aisle in which to turn and distribute itself. There is a very narrow door in the middle of each end; but this is used only for trainmen, who stand on a narrow ledge outside and operate the mechanism which opens and closes the entrances. The side door, opened by a station platform man, is still used for an exit, as heretofore.

A number of objections to the operation of these sliding doors by mechanical levers, at once suggested themselves; and the Elevated management, in its own shops, worked out a scheme of attaching a rod from an air-cylinder to the back of the door-frame inside the car siding, so that it would push in one direction and pull in the other, the compressed air to work the device being supplied from the storage tanks of the air-brake system. Although the pneumatic pressure is, in itself, enough to keep the door closed, an automatic lock, which the trainman releases by the pressure of his foot on a special lever, has been put on for additional protection. On the outer edge of the door, where it comes against the framing, there is a rubber cushion which not only breaks the force of contact, so that, if a person's hand should be caught between the edges, no injury would result, but overcomes the danger of a passenger's skirt or coat getting locked in at the risk of his being dragged by a train—for the slightest exertion will draw the garment through without the slightest risk of damaging it.

The Boston Elevated now has sixteen cars of this type in operation, running them in four trains of four cars each. The saving in time they accomplish, particularly at the large transfer stations and in the crowded aisles, is very appreciable, and may make it possible, eventually, to add at least one more train to the service.

END OF "EASY ACCESS" CAR.

The entrance doors of the Boston Elevated's new type of car are in the end of either side, giving immediate access to the sitting and standing space within, and allowing a broad aisle for the distribution of the crowd. A rubber cushion on the outer edge of the door protects passengers against any possible danger of injury. The mechanism controlling the pneumatic power by which the door is moved is on a narrow ledge outside the end of the car, on which the trainman stands.



Running a Generator or Motor

Rules of Practical Value to Operators for Preserving Mechanical Efficiency and Preventing Accidents

By F. B. CROCKER, E. M., Ph. D.
Head of Department of Electrical Engineering, Columbia University

AFTER any one of these machines has been properly started, it usually requires little attention while running; in fact, generators or motors frequently operate all day without any care whatever.

Starting and Oiling

In the case of a machine, however, that has not been run before, or has been changed in any way, it is wise to watch it closely at first. It is also well to give the bearings of a new machine plenty of oil at first, but not enough to run on the armature, commutator, or any part that would be injured by it; and to run the belt (if used) rather slack until the bearings and belt are in easy working condition.

If possible, a new machine should be run without load or with a light one for an hour or two, or longer in the case of a large machine. It is bad practice to start a new machine with its full load or a large fraction of it. This is true even if the machine has been fully tested by its manufacturer and is in perfect condition, because there may be some fault in setting it up or some other circumstance that would cause trouble. All machinery requires some adjustment and care for a certain time to get it into smooth working order. When this condition is reached the only attention required is to supply oil when needed, keep the machine clean, and see that it is not overloaded.

Regulation of Voltage

A generator requires that its voltage or current should be observed and regulated if it varies. The attendant should always be ready and sure to detect the beginning of any trouble, such as sparking, heating, noise, abnormally high or low speed, etc., before any injury is caused, and to overcome it. Such directions should be pretty thoroughly committed to memory, in order promptly to detect and remedy any trouble when it occurs suddenly, as is usually the case. If possible, the machine should be shut down instantly when any indication of trouble appears, in order to avoid injury and give time for examination.

Keep all tools or pieces of iron or steel away from the machine while it is in operation, as they might be drawn in by the magnetism, perhaps getting between the armature and pole pieces and ruining the machine. For this reason use a zinc, brass, or copper oil-can instead of one of iron or "tin" (tinned iron).

Particular attention and care should be given to the commutator and brushes, to see that the former keeps perfectly smooth and that the latter are in proper adjustment.

Never lift a brush while the machine is in service unless there are one or more other brushes on the same side to carry the current, as the spark might make a bad burnt spot on the commutator, or might burn the hand.

Touch the bearings and field coils occasionally to see whether or not they are hot. To determine whether the armature is running hot, place the hand in the current of air thrown out from it by centrifugal force.

Special care should be observed by anyone who runs a generator or motor, to *avoid overloading* it, because this is the cause of most of the troubles which occur.

Personal Safety

Never allow the body to form part of a circuit. While handling a conductor, a second contact may be made accidentally through the feet, hands, knees, or other parts of the body, in some peculiar and unexpected manner. For example, men have been killed because they touched a "live" wire while standing or sitting upon a conducting body.

Rubber gloves or rubber shoes, or both, should be used in handling circuits of over 500 volts, and these should be subjected to tests at frequent intervals, so as to determine their condition. The safest plan is not to touch any conductor while the current is on: and it should be remembered that the current may be present when not expected, owing to an accidental contact with some other wire or to a change of connections. Tools with

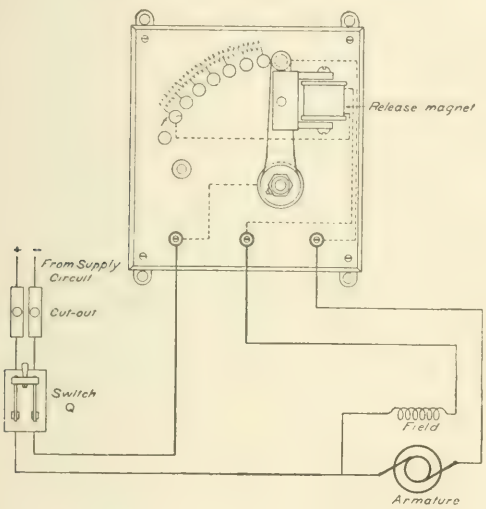


Diagram Showing Connections for Motor Starter.

insulated handles, or a dry stick of wood, should be used instead of the bare hand.

The rule to use *only one hand* when handling dangerous electrical conductors or apparatus, is a very good one, because it avoids the chance, which is very great, of making contacts with both hands and getting the current through the body. This rule is often made still more definite by saying, "Keep one hand in your pocket," in order to make sure not to use it. The above precautions are often totally disregarded, particularly by those who have become careless through familiarity with dangerous currents. The result has been that *almost all persons accidentally killed by dynamic electricity have been experienced linemen or station men.*

Stopping

This is accomplished by following substantially the same directions as for starting, but in the reverse order.

A generator operating *alone* on a circuit can be slowed down and stopped without touching the switches, brushes, etc., in which case the current gradually decreases to zero; and then the connections can be opened without sparking or any other difficulty.

However, when a generator is operating in parallel with others, or with a storage battery, *it must not be stopped or reduced in speed,* until it is entirely disconnected from the system; otherwise it will act as a short circuit. Furthermore, the current generated by it should be reduced nearly to zero before its switch is opened. This is accomplished by adjusting the field rheostat of the machine to be cut out, great care being taken that the change is gradual. If the reduction be rapid, the voltage of the machine may drop so low as to cause a back current to flow.

A *constant-current generator* may be cut into or out of circuit in series with others, and can be slowed down or stopped, or its armature or field coils may be short-circuited to prevent the action of the machine, without disconnecting it from the circuit. *It is absolutely necessary, however, to preserve the continuity of the circuit,* and not to attempt to open it at any point, as this would produce a dangerous arc. Hence a by-path must be provided by closing the main circuit around the generator, before disconnecting it. This same rule applies to any lamp, motor, or other device on a constant-current system.

Never, except in an emergency, should any circuit be opened when heavily loaded, for the reason that the flash at the contact points, discharge of magnetism, and mechanical shock which result, are decidedly objectionable.

A constant-potential motor is stopped by turning the starting-box handle back to the position it had before starting (see accompanying diagram); or, *if there is a switch (Q) connecting the motor to the circuit,* as there always should be, it should be opened, after which the starting-box handle is moved back to be ready for starting again.

Immediately after a machine is stopped, it should be thoroughly cleaned, and put in condition for the next run. When not in use, machines should, when feasible, be protected from dirt and moisture by covers of some waterproof material.

NESTLING IN A MOUNTAIN VALLEY.
Orange grove and cement irrigation canal, Riverside, California.

Western Irrigation

An Outline of the Work of the Reclamation Bureau Organized Under the National Irrigation Law—Address Delivered Before the Members of the American Society of Civil Engineers in Washington, D. C.

By FREDERICK H. NEWELL

Chief Engineer, U. S. Reclamation Service

IN a brief address before the Washington members of the American Society of Civil Engineers at an informal meeting, January 10, 1905, Chief Engineer Frederick H. Newell of the Reclamation Service — the bureau which is carrying out the provisions of the National Irrigation Law —outlined the organization of his department, and the remarkable rapidity with which a large bureau has been formed and some 300 engineers brought into close working relation since the passage of the Irrigation Law, June 27, 1902.

Work under Way

"The work of the Reclamation Service," said Mr. Newell, "is being carried on in thirteen States and three Territories in the West. We have now a fund available for construction, of about $25,000,000. This fund is both automatic and revolving. Without further act of Congress, all moneys received from the sales of Western public lands are covered into it, to be expended for irrigation works. At the same time the law provides that, when the works are constructed, their cost shall be apportioned among the lands irrigated by them, and this cost paid back by the settlers who take the land. These payments are returned to the Reclamation fund, to be used over again for future dam and ditch building. The present annual increase to the fund from land sales is about $3,000,000; but with this revolving feature, our present amount means much more than its mere face value.

"Under this work we have made good progress on a number of Western projects. In Nevada, we have spent some million dollars in constructing a large ditch, and expect to

water about 100,000 acres next year. In Arizona, we are constructing a great dam on the Salt river, which will be one of the highest in the world and will create an immense inland lake supplying water for some 200,000 acres around Phœnix. In New Mexico, we have constructed an earth dam which will

sents some of the most remarkable irrigation features we have encountered, and under which possibly 300,000 acres can eventually be reclaimed. Oregon also has a promising project at Malheur; and Washington, one in which the preliminary work is well under way in the Palouse country. In Montana, we

LA GRANGE IRRIGATION DAM, MODESTO, SOUTHERN CALIFORNIA.

water a fertile tract near Roswell. In California, our engineers have been working upon several projects—one on the lower Colorado, known as the Yuma project, which has just been approved by the Secretary of the Interior and $3,000,000 set aside for the work. Another project is an interstate California-Oregon reclamation—the Klamath project—which pre-

have several great projects, on the Milk river, the Sun river, and the Yellowstone, the latter including land in North Dakota. In Idaho, on the Snake river at Minadoka, a magnificent storage project is being worked out. In Wyoming, on the Shoshone river, while we have what appears to the eye an ideal dam site, a narrow cut between giant and almost perpendicular

MODESTO CANAL, CALIFORNIA.
The surging irrigation flood which thrills the heart of every Westerner, and conjures up a picture of green alfalfa fields, laden fruit orchards, and prosperous homes.

granite cliffs, yet the engineering difficulties have proven great—we have had to drill 80 feet for bed rock—and the actual conditions as we find them entirely overturn our estimates made from preliminary surveys. This Wyoming project is a good example of the impossibility of accurately judging the cost of any great irrigation project, even after the most careful surveys. However, in this case the final outcome will be a full compensation for the work in overcoming difficulties. In Colorado, one of the most interesting engineering constructions in the country is being worked out in the Gunnison valley. Here the longest tunnel in the United States, some twelve feet in the clear, is being carried through the mountain to lead the dammed waters of the Gunnison out of their deep gorge onto the fertile lands of the Uncompahgre valley, the other side of the divide.

GOVERNMENT DAM SITE, SHOSHONE RIVER, WYOMING.
To store 3 000 acre-feet of flood water—sufficient to irrigate 150,0(0 rich acres two feet deep. Height of dam to be 210 feet.—Walls of Box Canyon, 700 feet high.—Diamond drills bored 80 feet below river bed before striking solid foundation rock.

"These are the principal projects, each one in charge of a supervising engineer. In addition we are investigating some dozens of others, many of which will doubtless prove as feasible and attractive as any which we have so far selected.

Boards of Consulting Engineers

"The Reclamation Service depends largely upon its Boards of Consulting Engineers, who, after detailed surveys have been made and the plans worked out on any particular project by the supervising engineer in charge, inspect the ground and pass upon the plans; and, as the work of construction progresses, these Boards visit the project from time to time, and are consulted upon any of the new phases which may arise.

"We have been trying to get together a body of engineers, largely composed of young men, who will combine enthusiasm with loyalty to the work and the Service. Unlike most other engineering works—the river and harbor work for instance—we have to consider additional questions besides those of engineering. We not only have to look out for good construction work, but, since the money expended must be returned to the Government, complicated questions arise—the selection of projects where

the cost will not be excessive, thus insuring settlement; the selection of good, tillable lands which have unfailing water supplies; the organization of water users' associations, and many detailed questions which confront us in most of the cases where the Government proposes to irrigate not only public lands but some lands which have already been taken up under the various land laws and are now in private ownership. Every acre redeemed must pay its proportionate share of the cost of the works, and we must be sure that all the land irrigated will be colonized so that the Government will get its money back from each project.

Avoids Mistakes of Bureaucracy

"In the organization of this corps of engineers our policy is to keep the Washington or headquarters part of the work in close touch with the field work. We are having now a ten days' conference of our principal engineers, where ideas are being exchanged, obstacles and difficulties discussed, and where each engineer is brought into close relations with the work of other engineers, with the administration of the office, and with the conditions here in Congress. At the same time our men stationed here at Washington must go out into the field and keep closely informed of the progress of the construction work. We arrange our schedules so as to allow each man to work approximately half his time in the field and half here.

"I believe that the best results cannot be obtained in any branch of the Government where it is attempted to supervise field work from headquarters situated at a great distance from the operations, and through men who by long absence from the projects must necessarily lose touch with the constantly changing conditions."

Watering the Desert

A Short History of the 300-Mile Pipe System Supplying Water to the Coolgardie Gold Fields and District in Australia

By L. H. ROBERTS

THE Coolgardie gold fields lie some 363 miles inland in a direct line from the port of Fremantle on the west coast of Australia. The region is to all intents and purposes waterless, there being in the old days only a few "soaks" and native wells available for a supply of water.

In the year 1892, the first discovery of gold in paying quantities was made near the site of the present town of Coolgardie. When the great rush following this discovery set in, the want of water caused indescribable suffering and loss of life. The Government did all that was possible to minimize this suffering and loss due to the shortness in the supply of water. When it is stated that inferior water, hardly fit for human consumption, was worth sixty cents per gallon, and very scarce even at that price, some idea of the condition of affairs may be conveyed to the reader. As the mines developed, salt water was found, which was distilled and sold at about $17.00 per thousand gallons. The cost of water to the railroad company was $5,000 per day during the summer. By the use of the distilled water, some sort of provision was made, but the water supply still remained a point of critical danger in connection with the fields. An attempt was made to obtain water by boring, but, after going down

HELENA WEIR

3,000 feet through granite, the attempt was given up.

At the end of 1895, it was publicly announced that the Government intended to carry out a scheme for supplying fresh water to the gold fields by means of pumping from the coast. After months of work and inquiry, the engineer-in-chief reported in favor of a scheme which consisted in the building of a reservoir on the Helena river about twenty miles from Perth, the water to be then pumped through a main to Coolgardie. It was estimated that 5,600,000 gallons per day would be required, and the cost was set down at $12,150,000.

PUMPING STATION No. 5.

Work to Be Done

The final plans embodied a main supply reservoir situated in the Darling range about thirty miles from Perth, 320 feet above sea-level, where two great arms of granite jut out across the narrow valley at the bottom of which flows the Helena river. A gigantic dam of concrete was placed like a huge wedge between these two granite arms, thus closing up one end of the valley. This dam is 760 feet long, and 100 feet high in the deepest part, the foundations in addition, being carried down nearly 100 feet below the level of the river. At the base of the foundations, the thickness of the dam varies from 85 to 120 feet, tapering to a width of 15 feet on the top. About 69,000 cubic yards of concrete was used in the construction. The surplus water flows over the crest of the dam. The reservoir or lake thus formed is eight miles long, and contains, when full, 4,600,000,000 gallons of water. Suitable valve towers, shown in the accompanying illustration, are provided, to regulate the flow to the first pumping station. In brief, the problem was to pump 5,600,000 gallons every 24 hours against a total estimated head (including friction) of 2,700 feet, through a pipe 30 inches in diameter and, roughly, 330 miles in length.

Because of the peculiar conditions of the country and the great distance to be covered by the line—which is nearly as great as the distance between New York and Buffalo, it was found best to provide eight separate pumping stations. In each of the Stations 1 to 4, there are three complete sets of pumping machinery and boilers, any one of which is capable of pumping 2,800,000 gallons per day against a head of 450 feet, so that, to get the full quantity of water required, two sets of engines and pumps are always pumping together into the main, and one set is "spare." In the case of Stations 5 to 8 inclusive, there are at each station two sets of machinery, each set being capable of pumping 5,600,000 gallons per day against a head of 225 feet, so that while one set is pumping the other set is "spare." Each station is provided with concrete tanks of 1,000,000 gallons' capacity, which act as combined receiving and suction tanks. This brief description of the work to be done clearly shows how absolutely the financial success of

the scheme depended on the pumping machinery.

Triumph for American Machinery

It can be safely stated that the whole world was in competition, as the invitations to tender were not confined to any one country. After months of careful inquiry on the tenders submitted, the Government decided to accept the tender of a London firm, a special clause being inserted in the contract, giving them permission to have half of the manufacturing done by the Worthington Company. The sizes and types of engine selected were as follows:

PIPE CROSSING GULLY.

For Stations Nos. 1 to 4 inclusive:—Twelve (12) triple-expansion high-duty Worthington pumping engines of 300 H. P., each having two 16-inch high-pressure cylinders, two 25-inch intermediate-pressure cylinders, and two 46-inch low-pressure cylinders; and each having two 15-inch double-acting water plungers, all of a common stroke of 36 inches.

For Stations Nos. 5 to 8 inclusive:—Eight (8) engines of similar type, differing only in the water plunger, which is 21 inches in diameter.

Novel Features

From the sizes it will be seen that the only differene in the engines is that eight of them have 21-inch water plungers, and twelve have 15-inch. All the steam ends are standard to one size. The gain in economy is at once apparent, as this means that all the twenty boilers, with their accessories, etc., can be made standard, and the number of spare parts required to be held in store is greatly reduced.

The condenser is placed in the suction, so that all the water of the main passes through the condenser, and, as the volume is largely in excess of what is actually required, the temperature of the water in the main is not raised to any appreciable extent.

An ingenious arrangement for using the jacket steam has been carried out. As the steam passes from the jackets, it is taken and used to drive the feed pumps, which are of the usual Worthington boiler-pressure type. These feed pumps exhaust into the feed-water heater. By this means the feed water is sent forward from the heater to the economizer at a very high temperature.

The engine and boiler houses are of brick, and present a very fine appearance. Suitable overhead traveling cranes are provided, which can be operated from the floor of the engine house.

Tests

The result of the official trials illustrates the high efficiency and reliability of American machinery. The contract provided that each of the pumping engines should be capable of attaining throughout a 12-hour trial a duty of 135,000,000 foot-pounds of effective work per 1,000,000 British thermal units supplied to the engine, which would not be returned to the boiler in the ordinary course of working. The Government Engineer selected the groups of machinery at Station No. 2 and Station No. 8 for the purpose of making the official trials. At No. 8 the trial showed a margin of 8,000,000 foot-pounds of work in

favor of the engines. In addition to the above excellent performance, the quantity of water pumped was nearly 350,000 gallons in excess of contract requirements.

A problem scarcely second in importance to the system itself was the assembling and erecting of the plant, whose total weight was 3,500 tons. As has already been stated, there are twenty groups, each consisting of engine and boiler, distributed over 330 miles of country. It will be readily seen that if mistakes were made in consigning the machinery to its proper station, it would be very costly to rectify them. An ingenious system of shipping was adopted, which worked perfectly. Each group was given a distinctive color and letter, and every part of the group was painted with the distinctive group color to which it belonged. When the parts were cased, one end of the packing case was also painted with the correct group color. In addition, the cases were numbered consecutively, and each marked with the group letter. All marks were in duplicate, one set being painted on the case or package, and the other stamped on sheet-tin tabs which were fastened on the cases or packages. By these simple precautions, all trouble was avoided. The railway, shipping, and wharf men were supplied with colored group key plans, and so were able to pick out at once the various cases and packages belonging to each group, and to send them on to their correct destination. There were some 5,000 packages, and the only complaint received from the erection staff as to missing material referred to one ½-inch hydraulic valve.

Dinner-Pail Philosophy

¶ You cannot keep happiness to yourself.

¶ The love that is never wasted soon withers.

¶ A poor man does not need to be a poor sort of man.

¶ Depreciating others will not help the world to appreciate you.

¶ A man is not firm in faith because he is fossilized in mind.

¶ The pawnbroker acts as timekeeper for men who fight hard luck.

¶ Many a man who wouldn't think of telling a lie is an adept at side-stepping the truth.

¶ The greatness of our gifts may often depend on the smallness of our resources.

¶ A man may be loud and yet not say much.

¶ Heavenly mindedness is not earthly blindness.

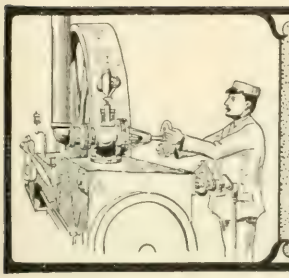
¶ Chance is one of the most profane words in our language.

¶ Many a man who is willing to do good is unable to make good.

¶ The man who suspects everybody is surely a suspicious character.

¶ It is unhealthy and undesirable for the cities to grow at the expense of the country.

¶ Shame is not in the confession of a mistake, but lies only in persistent, wilful wrongdoing.



ENGINEERING PROGRESS

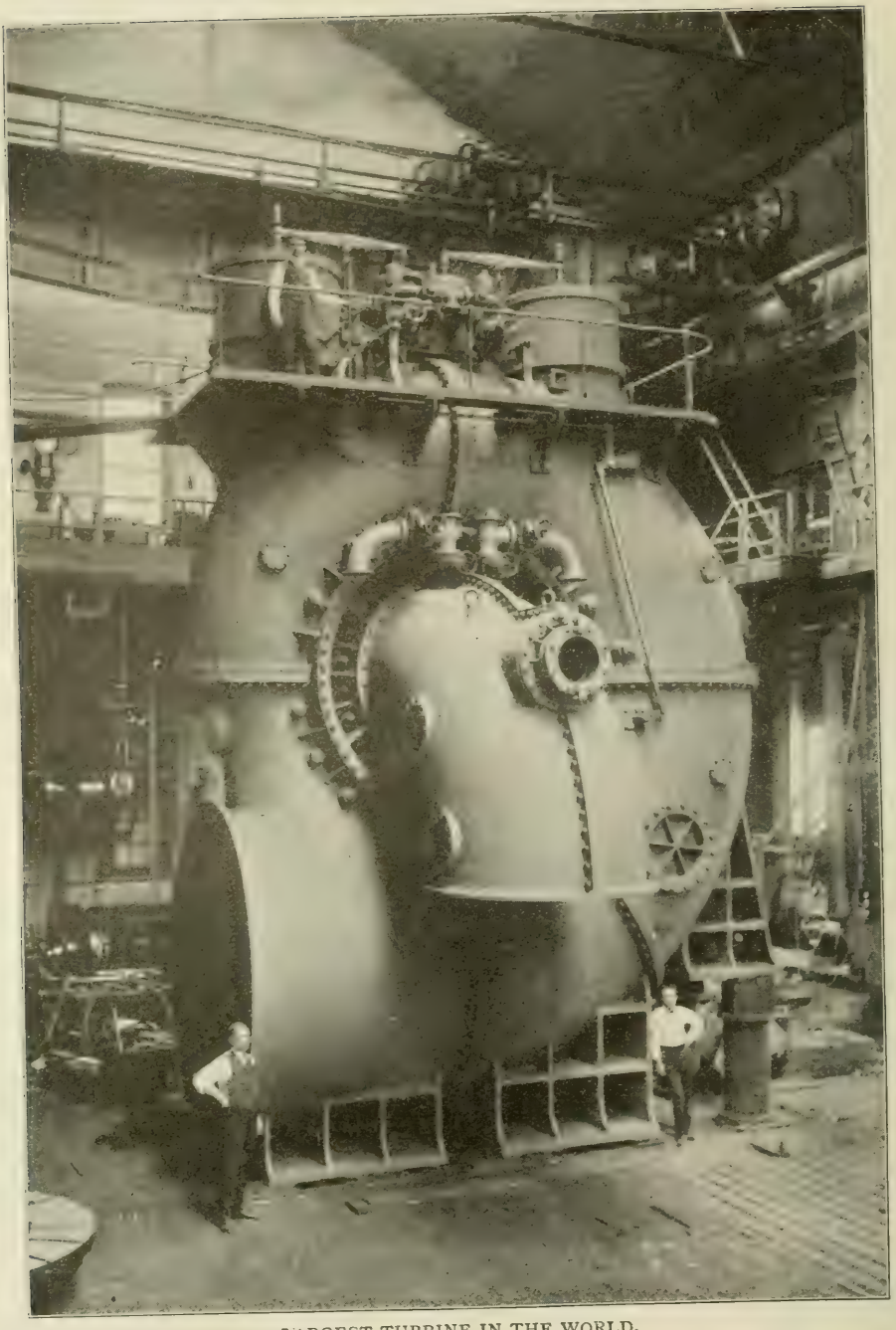
Passing of the Horse

THE automobile has been put to a remarkable variety of uses in the United States, but it is probably the record of a physician in Ohio to use it first for leading horses. Dr. C. R. Pontius, of the town of Fremont in that State, owns a touring car, as well as a horse which he has been using for driving purposes. He recently arranged to leave the animal on a farm near the town during the winter season, and, after thinking the matter over, decided the best way to take the horse to his new home was to tie it behind the auto, so that he would have a vehicle which would carry him back to Fremont with its own power. The accompanying photograph shows the automobile leaving Fremont with the horse attached. At the time the photograph was taken, an electric car happened by; and the picture, accordingly, shows three kinds of motive power—electric, animal, and steam—each of which has played, and is destined still to play, an important part in the evolution of social and commercial life. We have—possibly through some lack of "up-to-dateness," partly through some love of we know not what—labeled this picture "The Irony of Fate." This, however, is certain—that among the "relics" of days that are fast dropping behind in the march of events, giving place to the varied types of mechanical locomotive power that the necessities of our strenuous modern life have developed, the "faithful friend of man" will long retain supreme place in the affections of those who delight in the charm and mystery of the *living* and the *intelligent*.

THE IRONY OF FATE.—PASSING OF THE HORSE.

World's Largest Turbine

A TURBINE which swallows every minute a volume of water equal to a river 88 feet wide and 10 feet deep with a constant flow of 60 feet a minute, has been installed by a Canadian power supply company. The spread of electricity as an effective method of wide distribution of motive power to small manufacturing establishments, and the development of the turbine as the most effective means of transforming the



LARGEST TURBINE IN THE WORLD.

Installed at the Shawinigan Falls Power Station on the St. Maurice River, about 84 miles northeast of Montreal, Que.—Weight, 364,000 pounds; height, 30 feet; weight of wheel, 5 tons; weight of 22-in. shaft, 10 tons; intake, 10 feet in diameter; amount of water passing through per minute, 395,000 gallons.

power of streams into electrical current, have caused the turbine to increase in size by leaps and bounds, until this, the largest turbine in the world, is the result.

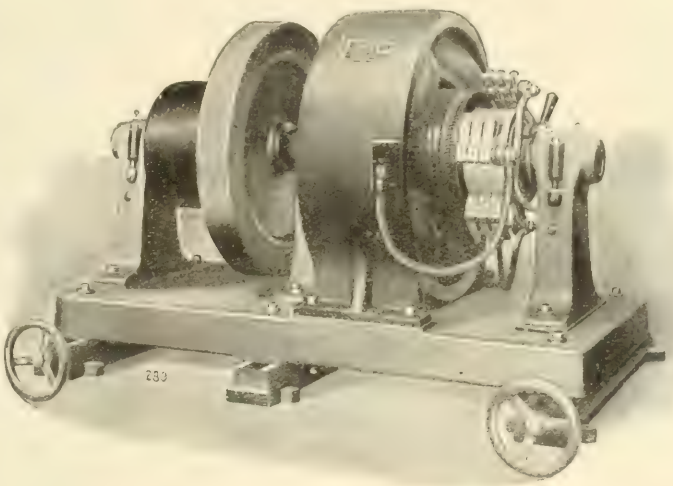
This colossal machine is of 10,500 horse-power, is 30 feet from base to top, 22 feet wide over all, and weighs 364,000 pounds. It was built in less than four months by the I. P. Morris Company, Philadelphia, Pa., for the power company of Shawinigan Falls, Quebec, Canada. An idea of its immense size may be had from the fact that, in shipping, five flat cars and one box car were required to carry it, and a special route had to be selected where bridges were high enough to admit of the passage of the huge parts.

The Canadian company which will use the big turbine has its plant 84 miles from Montreal, the water being furnished by the St. Maurice river, which empties into the St. Lawrence. The company furnishes electric power for street railways and other industrial purposes in the city of Montreal; and the big turbine will be one of several to generate power for this purpose, transmitting the current at 50,000 volts. The company has already developed 22,500 horse-power; and, with the addition of the new turbine, will have 33,000 horse-power. The river is capable of furnishing 100,000 horse-power. Of the present output of the station, about 10,000 horse-power is sent to Montreal. Shawinigan is now a booming town of 5,000 people.

With an intake ten feet in diameter, the water, after going in, is dicharged through two draft bends, one of which appears in the photograph. The wheel proper makes 180 revolutions a minute, with a head of water of 125 to 135 feet, acting on the turbine; and the quantity of water passing through the turbine when developing full power is 395,000 gallons a minute.

Dynamo for Gas-Engine Drive

THE accompanying cut illustrates a line of direct-current generators built especially for use in connection with gas and gasoline engines. The irregular impulses of such engines are offset by means of a fly wheel, which serves to overcome fluctuations of the dynamo speed, thus producing a steady light, which would be impossible were the irregularities of the engine speed to be reproduced in the armature of the dynamo. This requirement heretofore has sometimes been met by placing a heavy fly wheel on an extension of the armature shaft without providing any additional support for it. This method has, however, been somewhat unsatisfactory, because of the extra weight of the fly wheel which the bearings were not heavy enough to sustain. The machine mentioned has an extra heavy shaft extended to receive a heavy fly wheel which is supported by three bearings, two of the latter being placed close to the fly wheel on either side where they will support its weight and receive the extra strain caused by the jerking of the dynamo belt, without injurious effect on the dynamo. These three pedestals, with the machine frame, are mounted upon a heavy iron base, the latter being carried upon slid-



THREE-BEARING D. C. GENERATOR FOR GAS-ENGINE PLANT.
20 K. W.; 250 Volts; 750 R. P. M.

ing rails, so that the belt tension can be adjusted by means of hand wheels and thrust screws. The machines are the product of the Commercial Electric Company, of Indianapolis.

A Great Flume

A LARGE and expensive flume has recently been constructed in Eldorado County, California, which conducts water from the South Fork of American River down to Placerville. The total

A Mountain Flume in California.
Constructed by the American River Electric Company.

length of the flume is over five miles, though added to this is about two miles of canal—making seven miles in all. The total cost of ditch and flume was approximately $200,000.

This artificial waterway is capable of carrying 10,000 cubic feet of water per minute. The fall averages 5 feet 3 inches per mile, and the rate of flow is about two miles per hour, furnishing ample power for all purposes required.

This great improvement was made by the American River Electric Company of San Francisco. About five months were required to complete the work—a large force of carpenters and laborers being employed. Over 1,500,000 feet of lumber was used in building the flume alone.

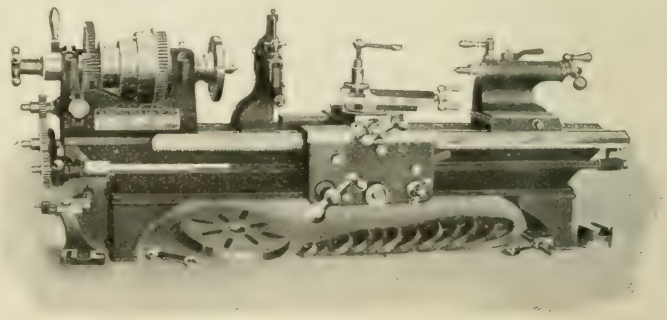
The purpose of the construction is to furnish power for operating the American River Electric Company's immense works at Placerville—a plant which cost over $250,000. The power generated will be employed, not only in lighting the large town of Stockton, Folsom, and other distant points, but will be utilized in driving mining plants in several large mines; also various kinds of machinery, mills, etc.

The flume was constructed for the greater part of the distance along the sides of steep hills. In some places a certain portion of the earth and rocks could be used for the upper side and bottom of the flume; but at all points more or less timber and lumber were necessary. There is one stretch where the flume is solid and unbroken for over three miles. Along much of the distance the flume is high, and supported by strong trestles.

Screw-Cutting Bench-Lathe

A BENCH-LATHE of moderate price that can be used profitably in all kinds of fine, accurate manufacturing and precision service, is known as the "Star Special" screw-cutting bench lathe, manfactured by the Seneca Falls (N. Y.) Manufacturing Company. It is claimed that this lathe is capable of performing much of the work now done on larger and more expensive tools.

The head-stock has a large, hollow spindle, made from a crucible steel forging, with draw-in chuck for split-cutlets up to ½-inch capacity. The cone-pulley has three steps for wide belt, and, with strong back gears, gives six changes of speed. The cross-feed screw has a graduated collar, which reads in thousandths of an inch and which can be set at zero in any position. The base is graduated 180 degrees, and renders the compound rest



Screw-Cutting Bench Lathe.

CHICAGO POLICE OFFICER EQUIPPED WITH MOTOR CYCLE.

capable of fine adjustment. The range of feeds is very large; and the range for screw cutting is extra large, cutting all standard threads, right or left, including 11½-inch and 27-inch, from three to sixty-four without compounding the gears, and nearly all threads by compounding. Transporting gears and index may be obtained for cutting International Standard Metric threads from 0.5mm. to 8mm.

The bed of the lathe is 46 inches long. The rated swing is 9 inches; but the machine has an actual swing of 10 1-3 inches over bed and 24 inches between centers.

Motor Cycles for Policemen

MOTOR cycles for capturing offending automobilists, are the newest equipment of the Chicago park police. Horses have proved inadequate to the task, as the automobile found to be violating the speed limit could always out-race the policeman, and the offenders—men and women—would often wave their handkerchiefs in derision at the distanced horseman in pursuit. Now the race is one between motor cycles and the automobile, the results are different. Exciting contests may often be witnessed in the Chicago parks. While the automobile is generally the speedier, the motor cycle has the advantage in its superior mobility. When two or three of the little puffing machines start after a big tourist or racing car, they dart through the narrow cut-offs, over the lawns, and across corners, and the automobile soon finds itself headed off. Numerous captures have been made as a result of the new innovation. Automobilists, in consequence, have been taught to show greater respect for speed laws.

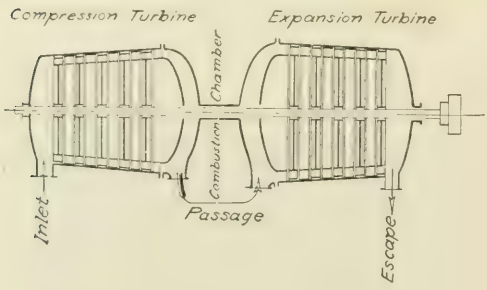
Stolze Gas Turbine

THE accompanying photograph represents a rather promising type of gas turbine, which is being brought out in Berlin, Germany, by the *Gasturbinen Gesellschaft Stolze*.

On a common axle are mounted two sets of turbines of different design. One of the sets serves as an air-compressor pump, while the other drives the shaft

STOLZE GAS TURBINE.

by means of heated air. Both of these sets consist of several rows of guiding vanes fitted to the engine casing; and of several rows of running vanes of a corresponding design, which are fitted to a common rotating cone, turning round along with the shaft. One of the sets of turbine vanes will suck fresh air, compressing it to a given pressure through a preheater, which is heated with exhaust gases, and conveying the greater part of it into a chamber lined with fireproofing material. The smaller part is conveyed beneath the grate of a producer, where it gasifies a convenient fuel. The gas thus formed penetrates into the above-mentioned chamber, to be burnt there in suitable burners by the compressed air to carbonic acid and water vapor, while evolving large amounts of heat. The resultant gases penetrate into the second turbine system, where they yield useful work by expansion in traversing the various steps. The process is thus mainly analogous to the cycle characteristic of all combustion engines, which consists of a suction of air, followed by compression, mixing with fuel, combustion, expansion, and discharge. In most of the gas motors now being built, the mixing, it is true, takes place before compression; and the combustion,

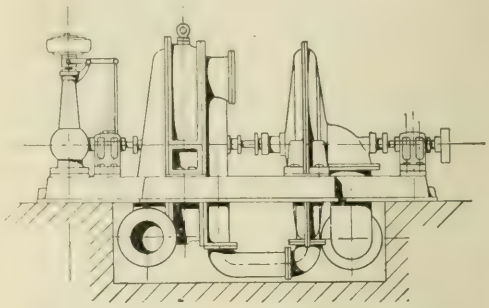


Stolze Gas Turbine.

under increasing pressure. The working cycle of the gas turbine most resembles that of the Diesel motor.

The efficiency of the turbine is doubtless susceptible of being increased beyond that of any existing type of prime mover. The Carnot cycle, for instance, is approached more closely than with any other design of motor.

Instead of producer gas, any other kind of gas evidently can be used, as well as carbonated air or benzine, alcohol, or petroleum vapors. The high practical importance of this system for automobile construction, which so far had available



Elevation of One Type of Stolze Gas Turbine.

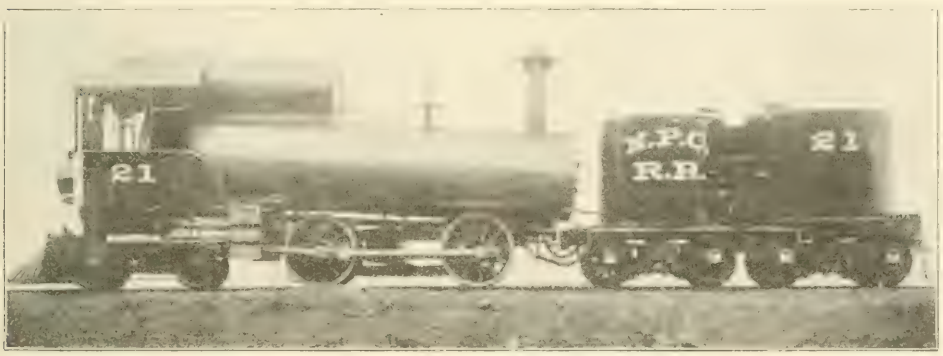
no other smoothly running motors than electromotors in connection with accumulators and their drawbacks, need hardly be pointed out.

The gas turbine obviously combines the individual advantages of both the steam turbine and the reciprocating gas motor, and thus bids fair to become another powerful competitor to the reciprocating steam engine.—Dr. A. Gradenwitz.

An Oil-Burning Locomotive

THE Northern Pacific Coast Railroad Company, which operates a line eighty-seven miles long in California between San Francisco and the town of Cazadero, has been experimenting with the use of oil as a substitute for coal on its locomotives, and has recently provided an engine which has been tried with very satisfactory results. The locomotive embraces a number of novel features. It is provided with a boiler and smokestack of the same pattern as the ordinary steam locomotive; but, as will be noted in the photograph, the boiler is set upon the truck frame at a slight angle. The truck frame is also of the ordinary American pattern provided for medium-power passenger engines; but the locomotive is apparently built to run backwards, as the pilot, as well as the headlight, is attached

to the cab of the locomotive. The tender containing the oil tank and water tank is located in the rear of the locomotive, coupled to what ordinarily would be the front of the truck frame. The usual air-brake system is also provided, as well as flexible metal hose which conduct the oil and water to the furnace and boiler respectively. The oil conduit extends along the side of the boiler, and upward



OIL BURNING LOCOMOTIVE.

into the distributing tank, which is placed upon the top just forward of the cab. From this reservoir, copper pipes lead to the apparatus by which the fluid is forced in a jet or spray into the furnaces. The oil-burning apparatus and fire box do not differ from the equipment on the ordinary oil-burning engine. The water is admitted directly to the boiler tubes, which are so arranged that they can readily be cleaned of scale.

One of the advantages claimed for this model of engine is that, with the cab located in front instead of in the rear, the engineer has an unobstructed view of the track ahead, which forms an additional safeguard against collisions and derailments such as might be caused by a displaced switch or an obstruction on the track. The air draught through the cab, moreover, decreases the temperature, making the interior more comfortable, while it also aids the air suction in the furnaces. Since the flow of the oil and water is regulated by valves, merely the services of an engineer are required for all purposes, as the sources of supply are at all times directly under his control. The tanks on the tender are constructed of ordinary boiler iron, the oil reservoir being filled with crude petroleum. The truck frame and all of the mechanism except the boiler were built by the Baldwin Locomotive Works, according to the designs of Mr. James B. Stetson, president of the North Pacific Coast Railroad Company. The boiler was mounted upon the truck frame at the shops of the railroad company, where the tank tender was also built.

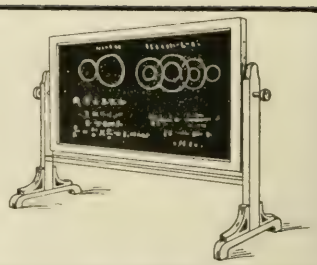
The locomotive has been in service several months, and, according to the statement of Mr. Stetson, has given entire satisfaction. At the present cost of oil in California, the locomotive is operated at about 50 per cent less for fuel than coal-burning engines on the same railroad developing an equal amount of power.

Electrification in England

"EVERY railway in the United Kingdom," says the *London Sphere*, "is now considering the question of electrification. The rapid spread of the electric trolley-car system all over the country, connecting town with town and village with village, has affected the suburban receipts of several railways. Two great lines are hoping to postpone the day of electrification by the adoption of 'decapods,' ten-wheel tank engines capable of hauling greater loads than any locomotive hitherto built for suburban traffic."

CHALK TALKS

by CARL S. DOW.



Number Thirteen—Graphs

IN reading a technical book or magazine, we often see curved lines drawn on paper ruled off in small squares. To the uninitiated these lines mean little or nothing; but to those who can understand them, they show far more than can be explained in many pages.

To interpret the meaning of these graphical representations, one must first of all know how they are constructed, and then, by careful study and practice, learn to read them correctly and formulate the laws they express. It is indeed surprising to see how plainly such a curve shows facts, and how much can be represented by a single line referred to fixed base-lines.

Principles of Construction

Before discussing the shapes of plotted curves, let us consider the method of construction.

The usual bases are two straight lines at right angles to each other. These lines are often called "rectangular axes." In Fig. 1 on the blackboard, *OX* and *OY* are the axes, and *O* (the intersection) is the "origin." If the perpendicular distances *AP* and *BP* are known, the point *P* is fixed—that is, its position relative to the axes is known. The distance *AP* is called the *abscissa*, and *BP* is called the *ordinate*, of the point *P*. The distances are also called the *co-ordinates* of *P*.

If we have a table showing these distances for a series of points, each point may be plotted. A simple case is a table of variables, such as is given below. In using such a table, one column may be taken for the abscissas, and the other for the ordinates. Thus a series of points represent graphically the data given in the table.

The following table was compiled from the results of a test of a steam turbine driving a generator. It shows the effects of increasing the vacuum:

Vacuum, Inches of Mercury	Pounds of Steam per K. W. per Hour
0	34.5
4	33.0
7	32.1
10	31.0
16	29.0
18	28.0
22	26.1
24	25.0
26	23.6

The plotted results are given in Fig. 2. The readings of vacuum are taken as abscissas, and the pounds of steam as ordinates. Thus we commence with no vacuum (atmospheric pressure), and 34.5 pounds. For a vacuum of 7 inches the ordinate is 32.1. Other points are located in the same way.

The curve shows that, as a more perfect vacuum is maintained, the steam consumption decreases.

Another Example

The following table appears in a recent government report. It gives the total tonnage of vessels built during the years 1891-1900 inclusive; it also gives the tonnage of vessels built on the seaboard:

Year	On Seaboard	Total Tonnage
1891	237,462	369,302
1892	138,863	199,633
1893	102,830	211,639
1894	80,099	131,195
1895	67,127	111,602
1896	102,544	227,097
1897	103,504	232,233
1898	112,879	180,458
1899	196,120	300,038
1900	249,006	393,790

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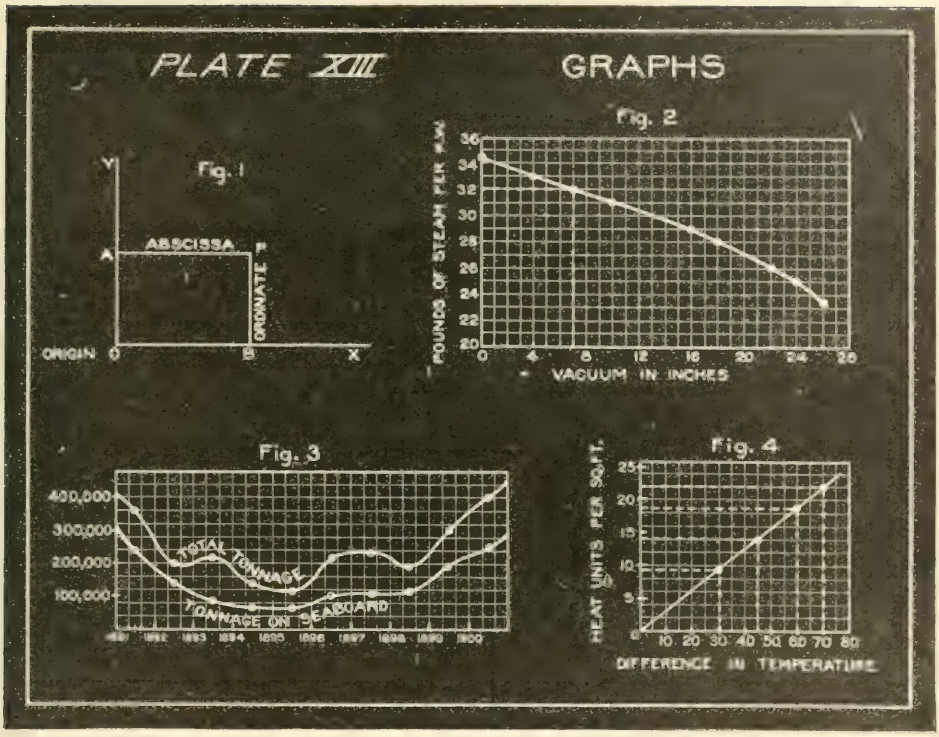


Unless studied very carefully, this table does not mean much. Contrast it with Fig. 3 on the blackboard. These curves are plotted in the same way as was the curve shown in Fig. 2. The dates are taken as abscissas, and the tonnage as ordinates.

It may be noticed that the point for the year 1891 is not taken at the origin, but at a distance corresponding to a half-year beyond. The reason for this is that the data in the table is for the whole year, and to get a point for plotting, the ordinate is placed at the middle of the space indicating the year.

It is well to note that the plotting of this curve differs in one respect from Fig. 2. In Fig. 2, all points are accurate, while in Fig. 3 it is impossible to take into account hundreds, tens, and units, unless the values are plotted on a very large scale. The form of the curve is sufficiently accurate, and expresses the principles.

Fig. 3 shows that there was a marked decrease in shipbuilding in 1894 and 1895. During 1896 and 1897 the totals were higher, but there was but little increase on the seaboard. Doubtless the general decrease was due to the hard times of 1893 and 1894. Probably an economist would tell us that the increase in 1896-1897 on the Lakes was due to the development of the iron ore trade on the upper Lakes, which caused the building of more ships to carry the ore. The increase in 1899 and 1900 may have been due to the Boer War, which decreased shipbuilding in England, and increased it in other countries.

Curves as Aids in Calculation

In engineering work, there are many cases in which constants to be used in formulæ are plotted in curves rather than expressed in tables. Take Fig. 4 as an example. In this graph, the number of heat units lost from a 12-inch wall is shown to vary as the difference in temperature varies. Thus, in calculating the size of radiators, we first estimate the probable difference between the temperature of the room and that of the outside air. Let us suppose this to be 60 degrees. Then by following the ordinate for 60 degrees we find that a square foot of a 12-inch brick wall will radiate 19 heat units per hour.

MOSCOW, THE COMMERCIAL METROPOLIS OF RUSSIA.
View showing the Kremlin

Life Stories of Successful Men

M. de Witte

President of the Russian Imperial Council

By WILLIAM A. COLLEDGE, D. D.

Professor of English Literature, Armour Institute of Technology

THE average American is very apt to be of the opinion that the United States is the only country where men are able to rise from humble surroundings to positions of national importance and great responsibility. The career of M. de Witte, however, who is to-day the greatest political force in Russia, is a flat contradiction of such a belief.

This man started life from a very insignificant position in the little town of Odessa, and by courage, good judgment, and hard work became the first statesman in Russia, taking rank with Gladstone and other famous leaders of European politics.

In young manhood, De Witte was appointed station agent in a small town of Southern Russia. While holding this position, the Russo-Turkish War broke out, and the Government immediately rushed troops and commissary supplies to the front in such abundance that the railroad was soon choked. In this crisis the officers of the road seemed to lose their heads, and everything was in a distressing muddle. At the outbreak of the war, De Witte was twenty-seven years of age, strong, clear-headed, and not afraid of work. Without any orders from his superiors, he stepped squarely into the breach and took upon himself the responsibility of keeping the line open. He contradicted orders, sidetracked special trains—in fact, took upon his own shoulders the entire management of the road.

The failure of his plans would have meant ruin, but De Witte had no thought of failure. He was ready to take the odds. With untiring judgment backed

by an energy that worked night and day, he straightened out the railroad tangle, and got the soldiers to the front and their commissary supplies after them. So well was the crisis handled that the Czar sent for the young station agent and personally thanked him.

Since De Witte's first government appointment, he has held the position of Minister of Means of Communication, Chairman of the Tariff Commission, Minister of Finance, and, finally, President of the Imperial Council of Ministers. To the last-named position he has been called as the one strong man in Russia upon whom dependence can be placed to work out a solution of the administrative problems arising out of the crises confronting the Empire in these days of foreign and domestic stress whose outcome is so uncertain.

M. DE WITTE.
President of the Russian Imperial Council of Ministers.

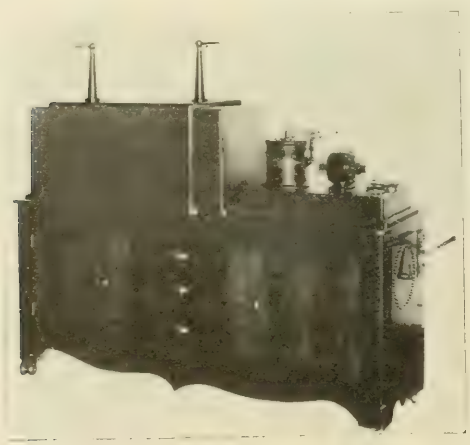
In reading the story of what this man has accomplished, and the manner in which he does things, one is impressed by two facts—First, that everything he knows he knows thoroughly; he has a thorough mastery of the details of work in the various departments that have been under his jurisdiction. Furthermore, his knowledge is accurate. Second, he is never afraid to take the initiative, to shoulder responsibility.

The career of this statesman, especially in Russia—a country that is in an extreme sense aristocratic—shows the trend of the present age—that what the age needs most is *the man who has the ability to do things.* The world does not care a snap whether you are the son of a grand duke or a rag-picker, if you have the stuff in you to do the things that the world wants to be done. Whenever a man, whether he is born in the United States or in the Fiji Islands, is able, in the slang phrase of the day, to "deliver the goods," his future is secure.

Largest X-Ray Machine

AN X-ray machine which is believed to be the largest in the world, has just been completed by the Carstarphen Electric Company of Denver, Colorado. The machine will be installed in the Phipps Agnes memorial sanitarium at Mont Clair. The contract for building the apparatus was awarded to the Denver firm after competitive bidding.

The complete apparatus occupies about the same space in a room as an upright piano. At the coil end of the cabinet, is a controlling switchboard. The dynamo and coils are all neatly enclosed in the cabinet, only a small part of the delicate and intricate machinery being visible. The sparkers, or spark-producing points, work perfectly 27 inches apart.



X-Ray Machine with Capacity of Over 1,000,000 Volts.

The sanitarium has its own power plant, the voltage being 110 direct current; and the apparatus is built specially for this voltage, being equipped with all necessary resistance coils and rheostats. Any part of the human body may be photographed by this machine, which makes an impression under exposure of less than ten seconds. The makers of the machine have received from Germany a number of glass tubes through which the current passes, enabling physicians to explore any part of the human anatomy which may be reached by any instrument now in surgical use. With this machine it is possible to obtain a current of 1,000,000 volts, enabling the operators to take a radiograph through an ordinary wooden wall, if necessary.

W. B. Carstarphen, who supervised the making of the machine, says of it:

"The coil is capable of generating a voltage of 1,000,000. The terminals are set twenty inches apart, and the discharge between them is a heavy flaming arc, the woodwork being of mahogany. The primary circuit is interrupted by a mercury jet interrupter working in oil. The cabinet comprises drawers and compartments for X-Ray tubes, fluoroscopes, screens, high-frequency treatment electrodes, cords, etc. Numerous accessories went with the coil, among which were double Oudin high-frequency coils; treatment stand, treatment chair, tube stand, extra large fluoroscope with special protecting screen, various forms of glass vacuum electrodes and some of Friedlanders largest-sized X-ray tubes. This made an exceptionally fine and powerful outfit, and an outfit with which a skiagraph of any part of the human body can be taken in ten seconds or less."

Recording a Ship's Vibrations

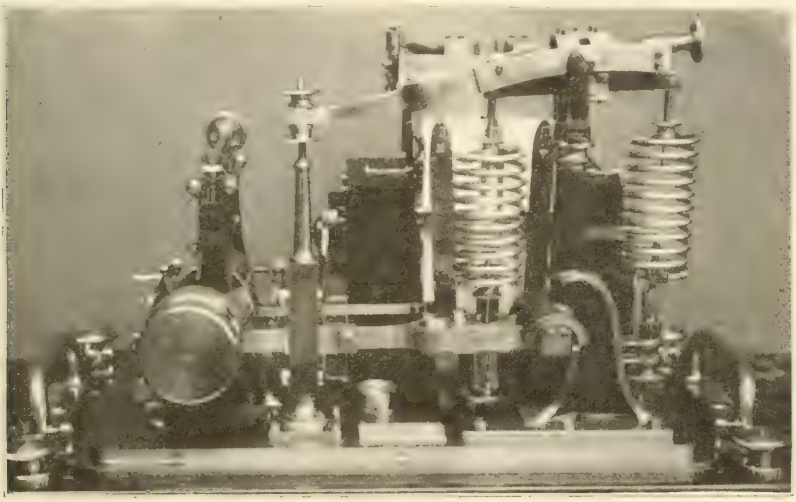
THE work done by Mr. Otto Schlick, of Hamburg, Germany, in formulating valuable rules for diminishing the vibrations of steamships, is universally known, it being mainly due to his investigations that ocean liners are enabled to cross the

Atlantic at the enormous speed of up to 24 knots an hour. After recently designing an apparatus for diminishing the rolling movement of a ship and thus preventing seasickness (see THE TECHNICAL WORLD for August, 1904, p. 735), the same experimenter is now bringing out, in conjunction with Mr. H. Maihak of Hamburg, an apparatus for recording the vibrations of steamships.

The "Pallograph," as the apparatus is called, traces the vibration amplitude of the keel (where the instrument is located) by means of two steel pens, upon a strip of paper, which slowly unwinds. The device is driven by clockwork, both for the vertical and horizontal vibrations. A third pen, impelled also by clockwork, produces each second a trace on the strip of paper. There are, in addition, one to three further pens (according as the steamer has one, two, or three engines and propellers), which are electrically driven from the engine. It may be mentioned that every engine part is fitted with a contact disc, which allows, with a given position of the crank, an electric current to be sent to the electro-magnet of the apparatus, actuating the recording pens concerned. At the moment of the crank occupying a given position (being, for instance, at the dead point), a mark will thus be traced on the strip of paper.

An additional steel pen may, if desired, be arranged, to be moved by an electro-magnet, which is to be actuated by a push button on the bridge. This arrangement is especially suitable for trial trips on the measured mile.

The curves of the diagram supplied by the apparatus give an accurate indication of all the important data, such as would be impossible to obtain in any other way. From the shape of the curve, the amplitude of vibrations and the periodical fluctuations are inferred, for both the vertical and the horizontal vibrations.



THE PALLOGRAPH.
An instrument for recording the vibrations of steamers.

The trace marked on the strip with each revolution of the engine, in connection with the time marks, next allows of the number of revolutions of the engine per minute being ascertained correctly up to 0.05. The diagram likewise enables us to ascertain how many vibrations have happened during one revolution of the engine, and at which point of the amplitude the part of the ship concerned happens to be, when a given engine crank passes through the dead point. The employment of the apparatus in running off the measured mile is of particular value, the apparatus indicating:

1. The exact time required for running off the mile, up to 0.05 second.

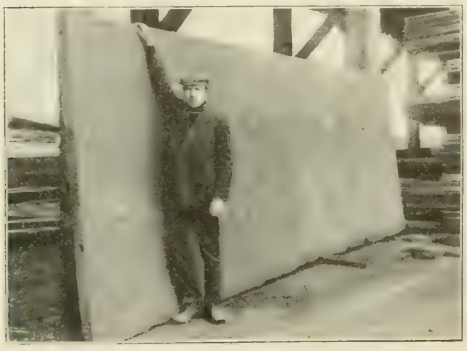
2. The aggregate number of revolutions of the engine, during the time required for running off the mile, up to 0.02 revolutions (provided the number of revolutions does not exceed 150 per minute).

3. The amplitude, frequency, and characteristics of the vertical and horizontal vibrations.

Mr. Schlick's investigations have brought out the fact that the number of revolutions of the engine is subjected to frequent fluctuation within one minute. It is consequently of particular importance accurately to ascertain the number of revolutions, in order to gauge the performance of the engine. An analysis of the curves (which first should be enlarged by means of photography) then allows of the causes of the vibrations being investigated, and eventually eliminated. The apparatus is therefore of the highest value, not only to steamers driven by reciprocating engines, but even more so to turbine steamers, enabling as it does the engineer to ascertain the faulty position of the propeller blades, which is one of the principal causes of vibration.—DR. A. GRADENWITZ.

An Immense Board

IN recent numbers of THE TECHNICAL WORLD, references have been made to, and pictures shown, of the gigantic timber trees characteristic of the Pacific slope. The accompanying photograph shows one of the products manufactured



GIGANTIC REDWOOD BOARD.
Cut from tree grown in Humboldt County, California.

out of these trees—an immense redwood board sawed from a log grown in Humboldt county, California. The board is 82 inches wide, and absolutely clear of defects such as knots or shake. The gentleman standing beside the board, is Mr. Folke Randel, a student of the American School of Correspondence, from whom we received the photograph.

A Swelled Head

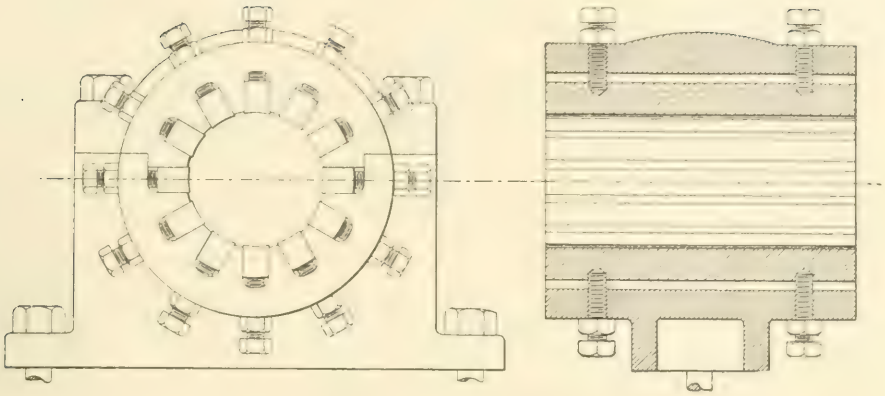
ONE of the worst cases of megalocephalic degeneration that has ever come to our notice, is shown in the accompanying engraving. The speci-

MAMMOTH MUSHROOM.
Found in North Evanston, Ill., Sept. 4, 1904. Diameter as shown by foot-rule, over 12 inches; circumference, 49 inches; weight, one-half pound.

men, which hails from North Evanston, is one of the genuine autochthones of the rich forested soil that abounds in the vicinity of that classic suburb of Chicago. It was discovered by Mr. Charles S. Radden on the 4th of September last. Whether, like other specimens of the over-obtrusive genus, it soon found itself "in the soup," we know not, though the record of its fate might have "pointed a moral;" but certainly its features, almost human in their display of unabashed effrontery and self-centered complacency, are fit to have "adorned the tale." "There are others"—mushrooms we mean—but certainly this one is entitled to immortal fame as the standard-bearer of our 20th-century advance in this region of the Middle West—the land of big things, big men, big stories, etc.

Adjustable Shaft-Bearing

AN adjustable bearing in which wear is compensated for while the journal is in motion, and which keeps the shaft



ADJUSTABLE SHAFT-BEARING.

at the same time in perfect alignment, is represented in the accompanying drawing. It was designed by Mr. G. W. Bates, a graduate of the American School of Correspondence.

The bearing consists of several brasses, which are supported in the pedestal by set screws. Each brass is supported by two of these screws, one at each end. As can be seen, the shaft may be adjusted in any plane parallel to the axis of the shaft, making it very easy to keep it in alignment. This form of bearing also offers exceptional facilities for keeping the journal supplied with oil.

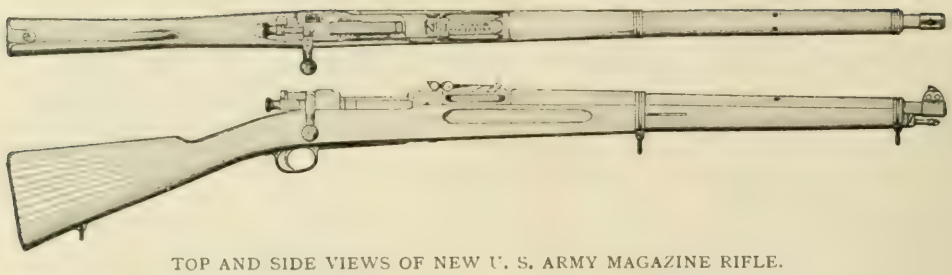
A Topsy-Turvy Photo

THE photograph reproduced in the accompanying illustration was taken because the landscape which it represents is very artistic. After the view was made, however, the photographer, on turning it upside down, discovered that another view had also been taken, caused by the reflection of the water. On reversing the picture, a group of houses can be seen through the woodland which intervenes between them and what appears to be a lake. In front of the lake is a driveway ending in a pier which projects into another body of water in the foreground. The view is what might be called a reversible or "topsy-turvy" picture caused by a curious combination of natural and artificial features.

World's Deadliest Rifle

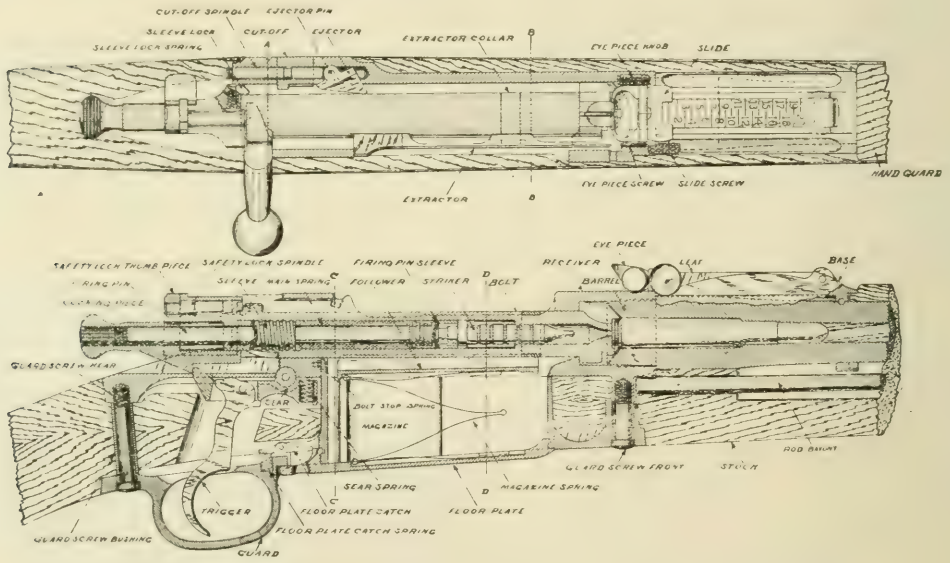
A NEW magazine infantry rifle, which experts declare to be superior to any other type in existence, has been constructed and adopted by the Ordnance Department of the United States Army. Nearly 100,000 of the new weapons have already been made in the government arsenals, and the entire Infantry service

REVERSIBLE OR "TOPSY-TURVY" PICTURE.
A rare coincidence caught by the camera.



TOP AND SIDE VIEWS OF NEW U. S. ARMY MAGAZINE RIFLE.

will soon be equipped with them. The most notable difference apparent at first glance between the old and the new arm is the fact that the barrel of the latter is entirely covered with wood. This innovation was the result of suggestions made to the Ordnance officers by the enlisted men of the army. Following the campaigns in Cuba and the Philippines, The magazine has a capacity of five cartridges, and can be filled with ease and quickness. When fully assembled, the gun weighs a little more than eight pounds, and, according to the Ordnance experts, is exceptionally well balanced, insuring ease of discharge and facilitating accuracy of aim—a feature of importance.



SECTIONS SHOWING MECHANISM OF NEW U. S. ARMY MAGAZINE RIFLE.

many complaints were made to the Ordnance Department by officers in the field, who said that after a period of rapid discharges the rifles became so hot that it sometimes was necessary to cease firing for a time to permit them to cool.

The bore of the new rifle is smaller than that of the old, the caliber being about .30 inch, while the initial velocity and the penetrating power are both greater. The new gun, also, is several inches shorter than the old. The ejecting lever projects downward in the new arm.

With an ordinary service charge, the maximum effective fighting range of the gun is 4,781 yards, or nearly 2¾ miles. With a full service charge, one of the new rifles, fired at fifty feet, drove its missile 54.5 inches into white pine butts, and through a steel plate nearly half an inch thick. The bullet used has a core of lead and tin composition in a jacket of cupro-nickel, and, when fired with a service charge, has a muzzle velocity of 2,300 feet a second.

In order to receive attention, all inquiries must be addressed to the Consulting Department, and must be accompanied with the *full name and address of the sender*. In view of the fact that the inquiries already received have far exceeded the available space, the Editors reserve the right to select for publication only those inquiries likely to be of greatest interest to the readers of the magazine in general. Other inquiries will be answered by letter.

Work Required to Compress Air, Power Developed, Etc.

Questions:—1. What is ordinarily the limit of pressure upon a compressed-air tank used for driving machinery or operating tools?

2. What would be the capacity in cubic feet of air of a tank 6 feet by 2 feet?

3. How much work would be practically required to fill the tank to its capacity?

4. With a compressed-air engine of ordinary efficiency, how many horse-power could be developed with such a tank?

5. What is the efficiency of an ordinary compressed-air engine when the pressure in the tank is quite low?—*A. F. S.*

Answers:—1. The ordinary pressure at which compressed air is used is 100 pounds gauge. For certain special work, however, pressures as high as 2,000 pounds per square inch are used. The compressed air used in operating engines of torpedoes is compressed to this pressure.

2. The capacity of the tank 6 feet long would be equal to its Length *multiplied by* the Area of its Cross-section, which in this case gives:

$$6\times 3.1416 = 18.8496 \text{ cubic feet.}$$

3. For each cubic foot of air compressed per minute to 100 pounds gauge pressure, there is required 1.5 horse-power. Since there are 18.85 cubic feet, the total power required to do the compression in one minute is 18.85×1.5 ($= 29$) horse-power. This is equivalent in round numbers to $30\times 33{,}000$ ($= 990{,}000$) foot-pounds.

4. The exact horse-power that could be developed by using the compressed air stored in the above tank would depend upon the rate at which the air is used, as well as the pressure of the air in the tank. The efficiency of the system starting with the work done in the compressor, would be about 50 per cent. As shown above, the work performed was 990,000 foot-pounds. Allowing, then, for an efficiency of 50 per cent, the available work would be 495,000 foot-pounds. The available horse-power would depend upon the rate at which the air is used. If used for one minute, the horse-power would be:

$$\frac{495{,}000}{33{,}000} = 15.$$

If, on the other hand, we wish to run a motor for one hour on the supply in the tank, the available power would be only $\frac{15}{60}$ (or $\frac{1}{4}$) horse-power.

5. The maximum efficiency of an engine of any size is in the neighborhood of 80 per cent—that is, of the total stored energy in the compressed air, the engine will develop at the brake .8. While the efficiency of compression is considerably lower at high pressures, yet, when used in a motor, the efficiency varies but little with different pressures.

CONSULTING DEPARTMENT (Continued)

Horse-Power and Design of Gasoline Engines

Question 1: Please tell me how to figure the horse-power of either a two- or a four-cycle engine.

Question 2: How can I find the right compression to use in an engine?

Question 3: Please give me the formula to determine the exact size of the inlet and exhaust valves.

Question 4: How do I find the diameter of a shaft, crank-pin, etc?—*S. W.*

Answer 1: To figure the horse-power of either a two- or a four-cycle engine, use the following formula:

$$\text{I. H. P.} \quad \frac{\text{A} \times \text{M. E. P.} \times \text{S}}{33{,}000}$$

in which A is the area of the cylinder in square inches; M. E. P., the mean effective pressure; and S, the impulse-stroke travel in feet per minute. S is found by multiplying the stroke (in feet) by the number of impulses or explosions in the cylinder per minute.

In a four-cycle engine with positive explosions, S will be ½ the number of revolutions per minute. In a two-cycle engine, there will be an explosion in each cylinder for every revolution. Consequently S equals the number of revolutions.

Answer 2: There is no exact formula for finding the "right compression." The compression in various engines is carried anywhere from 30 to 100 pounds or more. If the clearance is 50 per cent of the piston volume, the compression will be about 57 pounds absolute; if 40 per cent, 55 pounds; and if 25 per cent, 114 pounds. The compression can be calculated as explained in answer to the inquiry from *F. A. D.*, in THE TECHNICAL WORLD for November, 1904 (page 361).

Answer 3: So far there are no fixed rules applicable to the exact size of the valves. In general, the extreme diameter of the exhaust valve is made from ¼ to .4 the diameter of the cylinder; and the inlet valve, a little less, sometimes ⅓ the diameter of the cylinder.

Answer 4: For finding the correct diameter of the shaft, size of crank-pin, etc., the principles are the same as those involved in the details of steam engine design. For determining these proportions, we should refer you to a work on Machine Design, such as "A Manual of Machine Drawing and Design," by Low and Bevis; or "Elements of Machine Design," Part II, by Unwin.

Thermostats

Kindly answer the following questions through the Consulting Department of THE TECHNICAL WORLD:

Question 1: What kind of material is necessary to be used for thermostats for operating dampers, etc? Can steel and aluminum be used?

Question 2: How can the lifting power of a thermostat be calculated?—*H. C. R.*

Answer 1: Any durable and cheap metal with a high coefficient of expansion, such as steel and aluminum, is suitable for a thermostat.

Answer 2: The lifting power of the thermostat itself is very small, and in practice it is not relied upon directly to operate the dampers. The thermostat simply controls valves or sets in operation clockwork, which in turn control the valves operating the dampers. The less the work put upon the thermostat itself, the better.

The force produced by the expansion of metals can be determined by the formula expressing the modulus of elasticity:

$$\text{E} = \frac{\text{P} \times l}{\text{K} \times s},$$

in which P is the force in pounds per square inch; l, the length of the bar; K, the sectional area; and s, the extension due to the expansion. The modulus for aluminum is about 11,000,000; and the coefficient of linear expansion for one degree Fahrenheit is .00001234. The length of the bar, the cross-section, and the elongation are either known or readily determined. By substituting in the above formula, the stress per square inch necessary to give the elongation can be determined.

CONSULTING DEPARTMENT (Continued)

Brown Color in Steel

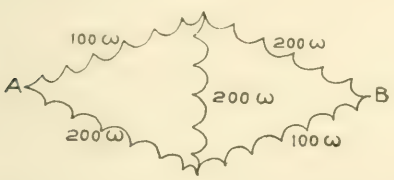
Question: How can the brown color sometimes seen in steel be obtained?—*W. P. G.*

Answer: Apply four coats of the following solution, allowing each several hours to dry. Brush after each coat if necessary. After the last coat is dry, rub down hard.

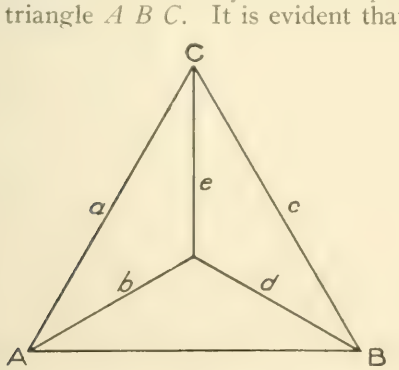
Sulphate of copper, 1 ounce.
Sweet spirits of nitre, 1 ounce.
Distilled water, 1 pint.

Divided Circuit and Resistance

Question: Kindly give me a formula which will apply to the following divided circuit to find resistance from *A* to *B*. The formula for divided or multiple circuits evidently does not apply, as the circuit does not seem to be a true multiple circuit—or, at least, I cannot see it as such.—*W. H. K.*



Answer: The solution of this problem is simply an application of the laws derived in connection with Maxwell's cycle method, as illustrated by the accompanying triangle *A B C*. It is evident that if



we disconnect the line joining *A* and *B*, then the resistance between the points *A* and *B* will be that of a circuit similar to the one you show, although a little distorted, it is true. Denoting the different resistances by *a*, *b*, *c*, *d*, and *e*, we have, according to the formula: Resistance between *A* and *B*

$$\frac{e(a+c)(b+d)+ac(b+d)+bd(a+c)}{e(a+b+c+d)+(a+b)(c+d)}$$

Substituting the proper values, we obtain 142 6-7 ohms as the resistance between the two points, which is the required answer.

Operation of Pump

Question: Why does a pump sometimes refuse to lift water while the full pressure is resting on the force valves, and how can this difficulty be overcome?—*W. H. A.*

Answer: The air in the pump chamber is not dislodged, but only compressed by the motion of the plunger. The trouble can be overcome by running without pressure until the air is expelled and water follows. Place a check valve in the delivery pipe, and provide a waste delivery to be closed after the pump has caught water.

Evaporation in Open Ponds and Reservoirs—"Mean Draught" of Pump

Question 1: Can you give a formula by which I can determine the amount of evaporation caused by atmospheric conditions, in the case of a reservoir or a lake?

Question 2: *(a)* What is meant by the "mean draught" of a pump? *(b)* How is it measured?—*N. S. F.*

Answer 1: There are no reliable formulæ for determining the amount of evaporation in the open air, for the reason that this varies with the climate and atmospheric conditions. Experiments made some years ago showed the evaporation, from a pan in the river, equal to an average depth of ⅛ inch per day, throughout the year. When the pan was in the air, the average evaporation was less than 3-16 of an inch per day. The average for August was ¼ inch per day; and for March, 1-12 inch per day. The above results were obtained in California.

At Mount Hope reservoir, Rochester, N. Y., the evaporation was 5.55 inches for the month of July, and 3.23 inches during October. These observations show that there is nothing very constant

CONSULTING DEPARTMENT—(Concluded)

about the rate of evaporation. Under the influence of warm winds, the evaporation would be greater than on a still day.

Answer 2: (a) The term "mean draught" refers to the average depth of the suction of a pump. It is the distance from the water level to the suction inlet on the pump. *(b)* The mean draught is usually measured in feet, which, of course, can be reduced to pounds pressure per square inch by multiplying by .433.

Milling Machine Indexing

Question: In a recent number of THE TECHNICAL WORLD, you gave the results for cutting the three sides of a triangle, but the method was not explained in detail. Kindly explain how to determine the number of turns necessary to cut a triangle with angles 90°, 75°, and 15°, on a machine in which 40 turns of the crank are required for one revolution of the spindle.—*G. F.*

Answer: In indexing, it is first necessary to determine the angle through which work must be revolved from any one position to the next cutting position. In the case of a triangle, the angle through which the work must be turned is found by subtracting the value of the angle under consideration from 180°. For instance, in this case we have

$$\begin{aligned} 180^\circ - 90^\circ &= 90^\circ \\ 180^\circ - 75^\circ &= 105^\circ \\ 180^\circ - 15^\circ &= 165^\circ \\ \hline & 360^\circ \end{aligned}$$

Now, supposing the work to be placed in the chuck, and one side of the right angle cut, then in order to cut the other side of the right angle, we must revolve the work through 90°. We multiply the number of turns of the crank required for one revolution (40) by a fraction whose denominator is always 360° and whose numerator is the required angle through which the work is to be revolved.

We have then $40 \times \frac{90}{360}$ (= 10) turns. Give the crank 10 turns, and cut the second side of the right angle.

We have next $40 \times \frac{105}{360}$ (= $11\frac{2}{3}$) turns, the number necessary for cutting the third side.

The next step gives us $40 \times \frac{165}{360}$ (= $18\frac{1}{3}$) turns, which number of turns would bring the work back to its original position.

There is no trouble in giving the crank a complete number of revolutions. To give a fractional turn, such as $\frac{2}{3}$, choose an index-plate having a circle with a number of holes that can be divided by the denominator of the fraction—in this instance by 3. A plate with 30 holes would be convenient in this case; and to give $\frac{2}{3}$ of a turn of the crank, we should pass the pin over $\frac{2}{3} \times 30$ (= 20) holes. For $\frac{1}{3}$ of a revolution, we pass the pin over $\frac{1}{3} \times 30$ (= 10) holes. The proof of the operation is that the complete number of revolutions of the crank brings the work back to its original position; thus, 10 turns + $11\frac{2}{3}$ turns + $18\frac{1}{3}$ turns = 40 turns, the number necessary for one revolution of the spindle.

Producer Gas

Question: What is Producer Gas? How is it made? What are its advantages?—*J. A. D.*

Answer: The product of gas producers, which is the cheapest form of energy from fuel, is called Producer Gas. It is used for heating and furnace work, and as a motive power for driving gas engines. For any of the above purposes, it is much cheaper than either illuminating gas or coal fires, the calorific value being about 140 B. T. U. per cubic foot.

This gas is made by passing a mixture of steam and air through an incandescent fuel bed in a closed gas producer. Nothing but ash remains after the fixed gases have been removed from the fuel. For use in gas engines and where burners are used, the gas must be cooled and scrubbed.

For furnace work the hot gas is led directly to the furnace from the producer without cooling or scrubbing. Care must be taken that neither too much steam nor too much air be taken in, as the gas must be of uniform quality.

The advantages are: Low fuel cost, maximum efficiency for fuel, maximum economy for power, absence of smoke, small space required, and no skilled labor needed.

Personal and Miscellaneous

Important Central Station Contract

THE CROCKER-WHEELER COMPANY, through its Pacific Coast managers, the Abner Doble Company of San Francisco, has secured a contract from the California Gas & Electric Corporation for three 4000-kilowatt 25-cycle 3-phase, 13,200-volt Crocker-Wheeler type alternators. These machines will furnish current to operate the United Railroads of San Francisco, in accordance with a contract recently secured by the California Gas & Electric Corporation. They will be direct-connected to Snow gas engines, the largest in the world for such service. The generators are to be of the revolving-field type of machine recently brought out by the Crocker-Wheeler Company; and the securing of the contract indicates that the important position this company has held in the direct-current field is also to be maintained in the alternating line. The generators are to operate at 88 revolutions. The installation of these engine-driven generating units in San Francisco will mark an important step for the transmission company, as they will operate in parallel with the water-power plants of the company, and thus serve as an important reserve plant for the entire system. One of the units will be used exclusively for handling the peak load on the railway lines.

American School Club in Canada

THE interest and enthusiasm displayed by the students of the American School of Correspondence in Toronto, Ontario, was recently manifested in the organization of a club known as the American School Club, the object of which is to provide a reading room and lectures on educational subjects for the benefit of its members. About twenty-five students inaugurated the movement leading to the establishing of the club, and a preliminary meeting was held September 20, 1904, at which a permanent organization was effected. Mr. Herbert Terry, past president of the Engineers' Association, of Toronto, was chosen president of the club, and arrangements were made for a lecture every two weeks.

The first lecture was given October 25, by Mr. Harkum, general superintendent of the Canada Foundry Company, whose subject was "The Successful Engineer." The next meeting of the club on November 8 was devoted to a "Chalk Talk on Electricity" by Mr. Wright, of the Canadian General Electric Company. The attendance at this meeting reached 125; and it had risen to 200 on November 22, when Mr. C. H. Acton Bond addressed the members on the subject of "Architecture." On December 20, an illustrated lecture on "Electrical Measurements" was given by Mr. G. J. Manson.

The great interest that has been manifested by members in the meeting of the American School Club, together with the large attendance called out by the lectures, gives the stamp of success to the movement.

Everything Goes

THE use of dogs, goats, and sometimes sheep, for drawing vehicles, is frequently recorded in stories about these

PRESSED INTO SERVICE.

animals, but it is a question if a rooster has ever before been harnessed for this purpose. A farmer out in Iowa thought one of his Shanghais was large and strong enough for the purpose, and made a harness of cord by which the fowl was attached to a little go-cart. The accompanying photograph shows the rooster hitched to the cart, in which is seated the farmer's little son. Including the boy and the cart, the rooster has to draw a weight of about thirty pounds, but hauls the load around the yard without difficulty. The reins are merely ornamental, as he is guided by someone going in front and coaxing him with corn or other food.

Renewable-Seat Valves

FOR places where extreme steam pressure is used, and where wear and tear on valves are severe, an improvement has recently been introduced, the details of which are shown in Fig. 1. The improvement consists of a removable seat for globe and angle valves. By unscrewing the nut on the bottom of the valve, all the parts become removable and accessible from the top, thus making it convenient to replace any worn part, or to substitute a new seat or disc when required. The disc is attached to the stem by a slot, making it easy to remove and replace. The disc and seat can also be removed, and the two ground together if necessary.

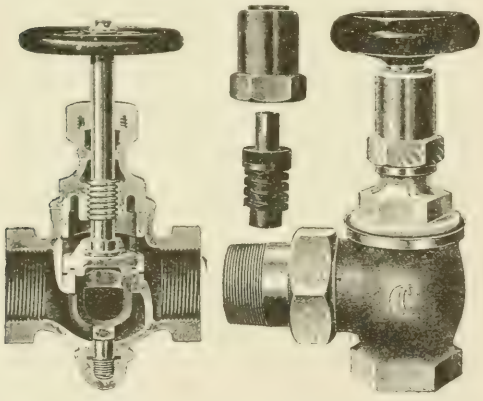


FIG. 1. FIG. 2.

TYPES OF RENEWABLE-SEAT VALVES.

In reassembling the valve, the seat is replaced and the nut on the bottom of the valve, which holds the seat in place, is tightened; the bonnet is then screwed on, and this valve may be closed ready for service. These valves are also constructed so that they can be packed when open, without the steam escaping. To do this, the valve should be opened wide.

The renewable parts of these valves are made of a special hard composition, which, it is claimed, will outlast many times the material employed in ordinary valves.

Fig. 2 illustrates a self-packing radiator valve which was designed to avoid leaky stuffing-boxes and the consequent escape of steam and water, which frequently results in damage to floors, walls, and ceilings. It has been found impossible to make a self-packing valve in which two metallic parts grind together, as these parts soon become worn and the valve leaks. This is obviated, in the valve illustrated, by the use of a piece of vulcanized rubber between the metallic parts, which makes a perfectly satisfactory seat; and if for any reason the vulcanized rubber becomes injured, a new piece can readily be inserted. The Crane Company, which makes both of the types of valves here shown, states that they have both been tested thoroughly in actual service, and have given uniformly satisfactory results.

Recently Graduated

THE following students have been graduated from the American School of Correspondence since the January number of THE TECHNICAL WORLD was issued:

Alvarez, Luis B., New Orleans, La.—Course: Electrical.

Anderson, Chas. L., Chicago, Ill.—Course: Stationary.

Asquith, Albert, Northboro, Mass.—Course: Locomotive.

Ayson, Ernest E., Otago, New Zealand—Course: Electrical.

Biddle, John E. Wm., Auckland, New Zealand—Course: Elementary Electricity.

Bootsgezel, J. J., Groningen, Netherlands—Course: Mechanical-Electrical.

Bruischaart, C., Walworth, N. Y.—Course: Elementary Electricity.

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Low yet appears high. Combines absolute comfort with style,—lots of it.

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Will dominate spring and summer styles for 1905 as no other shape has in years.

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Quarter sizes.

* * *

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CORLISS-COON COLLARS 2 for 25c

CORLISS, COON & CO. Dept. TW TROY, N. Y.

How Many Trips to the Laundry?

If you want to know which brand of collars is best value, take an indelible pencil and mark one each of several brands (any price), every time they go to the laundry. Then you can see which you get the most wear out of before you throw it away.

Corliss-Coon Helmet Brand Collars will get the most marks. Try it and see. The reasons are:

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RECENTLY GRADUATED—(Continued)

Camacho, Alex. A., Antigua, British West Indies—Course: Electric Lighting.

Carsley, Geo. F., Boston, Mass.—Course: Electrical.

Carter, Frederic W., New Bedford, Mass.—Course: Electrical.

Chambers, Guy Arthur, Gisborne, New Zealand—Course: Electrical.

Clark, Clarence E., Albany, N. Y.—Course: Electrical.

Clough, John S., North Haverhill, N. H.—Course: Mechanical-Electrical.

Crapnell, Clay, Joy, Ill.—Course: Stationary.

Creveling, Chas. S., Bloomsbury, N. J.—Course: Electrical.

Davis, J. Alder, Amherst, Nova Scotia—Course: Electrical.

Day, A. J., Jacksonville, Fla.—Course: Electrical.

Dowling, Harold L., St. Louis, Mo.—Course: Electrical.

Dunbar, Ernest A., Orange, Mass.—Course: Stationary.

Eames, Henry H., West Somerville, Mass.—Course: Shop Practice.

Edgecomb, Henry R., Edgewood Park, Pa.—Course: Electrical.

Edward, C. Louis, East Hampton, Long Island, N. Y.—Course: Marine.

Enright, Michael F., Temuka, New Zealand—Course: Marine.

Ferguson, Carl L., Ridgeville, Ind.—Course: Electrical.

Fernstrom, Herman O., Basel, Switzerland—Course: Complete Mathematics.

Ferry, D. S., Broomfield, W. Va.—Course: Electrical.

Fessenden, C. R., Hamilton, Ont.—Course: Mechanical-Electrical.

Fink, Herman J., Minneapolis, Minn.—Course: Heating, Ventilation, and Plumbing.

Frease, George E., Youngstown, Ohio—Course: Electrical.

George, E. M., Gaffney, S. C.—Course: Electrical.

Gowell, Robt. N., Fitchburg, Mass.—Course: Electrical.

Graves, Kinzie A., Mexico, N. Y.—Course: Electrical.

Hall, Jno. L., Downer's Grove, Ill.—Course: Electrical.

Henderson, Jas, H., Hyde Park, Mass.—Course: Stationary.

Higgins, A. E., San Diego, Cal.—Course: Mechanical Drawing.

Hiler, Frank E., Joliet, Ill.—Course: Locomotive.

Hill, Arthur St. John, Norwalk, Conn.—Course: Electrical.

Hudson, T. P., Houston, Texas—Course: Engineers' Course.

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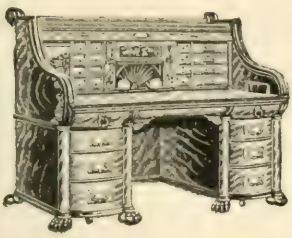

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Keithline, Samuel P., Wilkes Barre, Pa.—Course: Electrical.
Klein, Floyd A., Chicago, Ill.—Course: Mechanical Drawing.
Kreusch, Albert, Tonawanda, N. Y.—Course: Locomotive.
Lamb, N. Edw., Taunton, Mass.—Course: Electrical.
Osborne, Matthew, Wellington, New Zealand—Course: Elementary Electricity.
Parrott, Louis N., Lebanon, Ill.—Course: Electric Lighting.
Pierce, Eugene, Ilion, N. Y.—Course: Mechanical.
Pray, Henry, Traverse City, Mich.—Course: Electrical.
Rose, Cassius C., Paducah, Ky.—Course: Electric Wiring.
Rosene, L., Chicago, Ill.—Course: Electrical.
Roush, Leroy C., Chicago, Ill.—Course: Electrical.
Schneeberger, Boyd, Galion, Ohio—Course: Electrical.
Shannon, Irvine, Hoboken, N. J.—Course: Electrical.
Sheadel, James B., Churubusco, Ind.—Course: Electrical.
Siebler, Matthew, Dayton, Ohio—Course: Mechanical.
Silverthorne, Henry B., Brooklyn, N. Y.—Course: Electrical.
Smith, Lester I., Buckmanville, Pa.—Course: Locomotive.
Smith, Ralph, Warrensburg, N. Y.—Course: Electrical.
Sturgill, Perry, Glen Roy, Ohio—Course: Engineers' Course.
Sweatt, J. O., Sault Ste. Marie, Mich.—Course: Perspective Drawing.
Temple, Allen Porter, Lindale, Ohio—Course: Electrical.
Thineman, Ed., Wanatah, Ind.—Course: Electrical.
Torrey, C. E., Sault Ste. Marie, Ont.—Course: Electrical.
Torrey, Escar J., Winchester, Mass.—Course: Electrical.
Vandergrift, Jas., Showell, Md.—Course: Locomotive.
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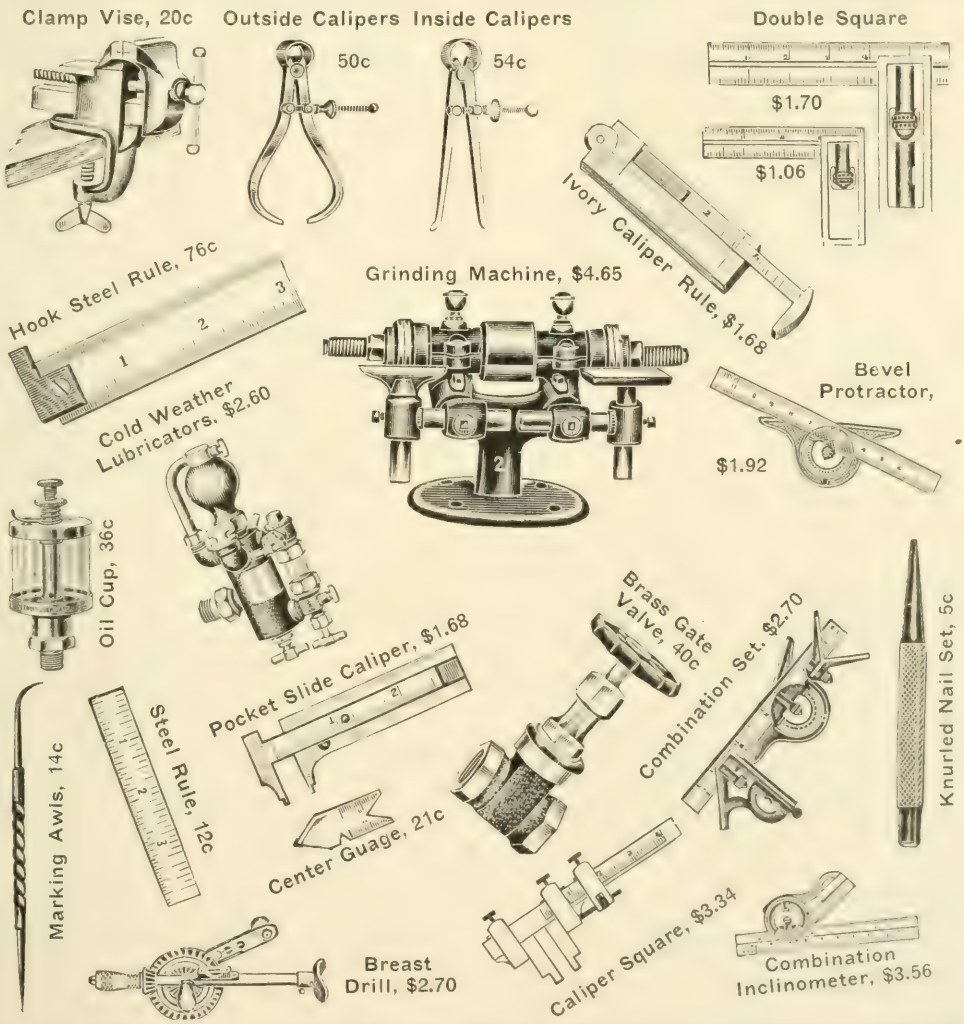

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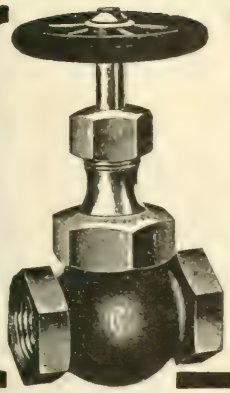
Personal Notes

HENRY C. MORTIMER, JR., of the General Electric Inspection Company, has joined the New York office staff of the Crocker-Wheeler Company. He will assist F. B. DeGress, manager of that office, and will succeed A. J. Thompson, who has accepted a position with the New York Branch of the Bullock Electric Manufacturing Company.

MR. C. W. WHITNEY has resigned his position as Pacific Coast Representative of the McGraw Publishing Company, New York, and has become identified with the Abner Doble Company of San Francisco, Cal., engineers and manufacturers of tangential water wheels and needle-regulating nozzles. Mr. Whitney will have charge of the Abner Doble Company's publicity department.

QUEEN & COMPANY (Inc.), of Philadelphia, makers of scientific appliances, have, to meet the increased demands of their business removed their instrument factory from Filbert street to the spacious Cornelius Building, 817-831 Cherry street. This move supplies the greater space and improved facilities required at the present time.

MR. THOMAS MELVIN, who has just completed the Electrical Course in the American School of Correspondence in a very creditable manner, has leased the electric lighting plant at Bowling Green, Mo., with option to buy, and intends to make several changes and improvements in the near future.



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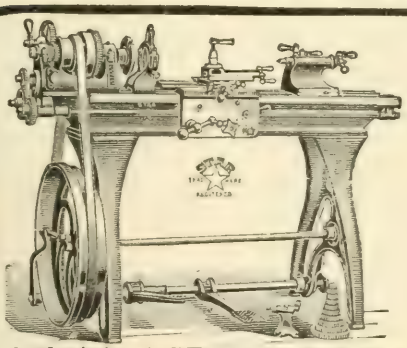

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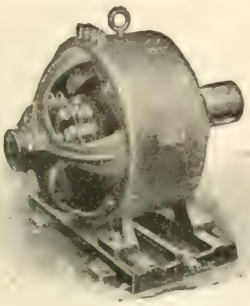

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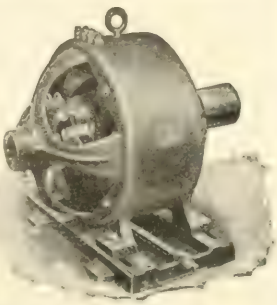

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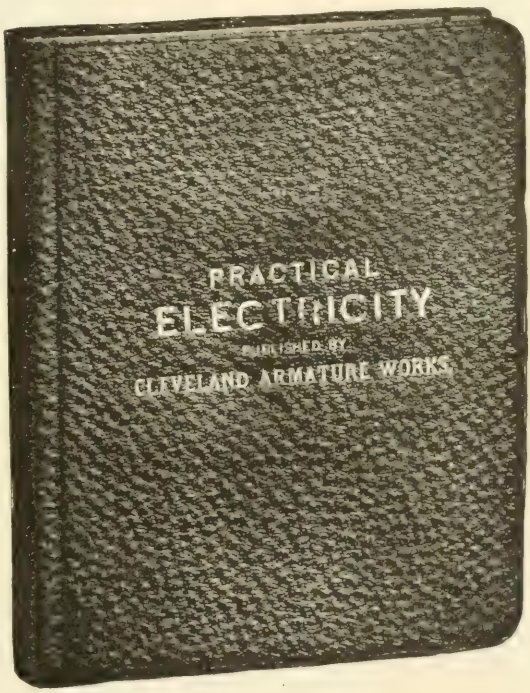

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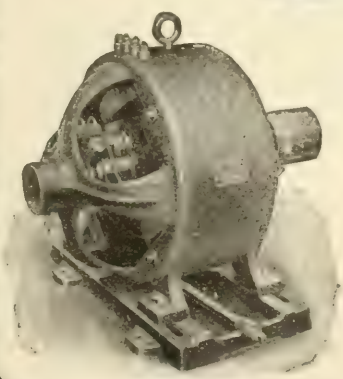

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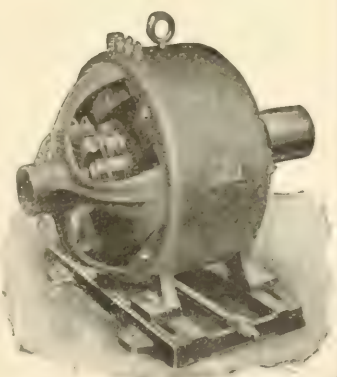

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BACON: Why?

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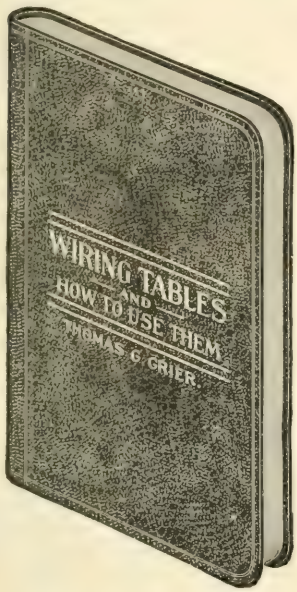

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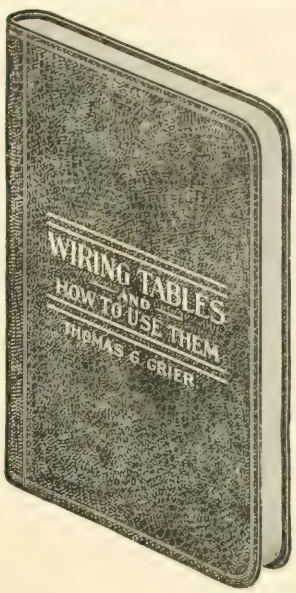

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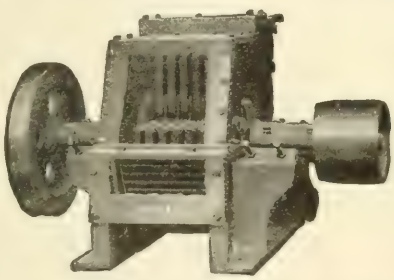

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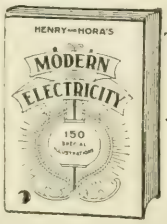

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A Modern Battleship. A half-tone engraving showing all details, exterior and interior, of an up-to-date battleship, all parts named and indexed. Printed on plate paper, 42 by 28 inches, with wide margin. Mailing price, rolled, in tube, 50 cents. Edition de luxe, mounted on linen and stretcher, in box, $5.00. Published by The Derry-Collard Company, New York, N.Y.

THE sea and all that pertains to it, have a fascination for almost everyone; and a good picture of one of the modern leviathans representing the acme of concentrated energy and engineering skill found in the types of ships that are the basis of sea-power, is not only an attractive ornament on the walls of office or home, but an object-lesson of great educative value. Few battleship pictures, however, have heretofore given anything more than the most superficial knowledge of the construction, equipment, and operation of the modern man-of-war. In that respect, this engraving stands in a class by itself. It represents two years' work of high-grade draftsmanship under supervision of naval experts, and graphically portrays the immense amount of machinery, guns, and fittings entering into the make-up of a battleship of the latest type. The index, covering nearly 500 named and numbered parts, is printed below the engraving, so that all details are available at a glance. Everything is drawn to scale, in its true position and relation to other parts. Even to the seaman—and to the landsman it goes without saying—this picture gives a wealth of information about a battleship, its guns, machinery, stores, appliances, and operative methods, which

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American Tool-Making and Interchangeable Manufacturing. By Joseph V. Woodworth. Pages 535. Cloth, 5 1-2 by 9 inches, 600 Illustrations. Published by Norman W. Henley Publishing Co., New York, N. Y. Price, $4.00.

THIS book is a very complete and practical treatise on the art of tool-making and the system of interchangeable manufacturing as generally practiced in the United States to-day. It contains descriptions and illustrations of the different types of small tools and special appliances which should be in general use in every working establishment where economy; capacity, and interchangeability of product are imperative. The book is divided into 33 chapters; and after a general discussion of the inception and development of modern interchangeable systems, the questions of designing machine tools and of tool-making are taken up, and in each of the succeeding chapters different classes of machine tools and special appliances are considered. The number of machines and appliances described is far too large to receive special mention within the limits of a brief review; but it may be stated in general that the work is a valuable one, and brings the subject thoroughly down to date. The information contained on the system of interchangeable manufacturing cannot fail to be of the greatest use to tool-makers, designers and die-makers, as well as managers of manufacturing establishments.

Electricity Made Easy. By Edwin J. Houston, Ph.D., and Arthur E. Kennelly, Sc. D. Cloth. Pages 348. Illustrated. Indexed. New York, N. Y.: McGraw Publishing Company. Price, $1.50.

THOUGH electricity, in its essential nature, is as much a mystery to the scientist as to the layman, the laws of its operation and the methods of its control for human uses, are well understood by electrical engineers. It has invaded almost all the economies of our domestic, commercial, and social life, and has been made to minister in a thousand ways to man's welfare and comfort. In the pres-

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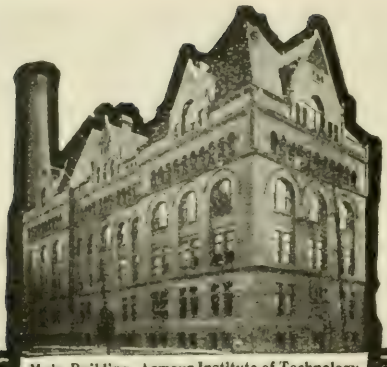
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ent volume, the way it does all these things is clearly explained for even the unscientific reader, in simple language and by copious use of illustrations. The electric lamp, for example, is a commonplace of every-day life; but how few know what it is, how it is made, how the mysterious current that animates it is produced and supplied! The pushing of a button rings a bell or "announces" a definite call. The clicking of a telegraph key will send an intelligible message across the country and to distant lands. The telephone will transmit the very tones of our voice to remote points. The shifting of a switch-key will set in operation powerful machinery. A hundred other applications to which the electric current is put, might be cited; but the mechanism involved and the operating principles are unknown to the generality of people. In giving full and explicit knowledge on all these matters, aided by graphic cuts showing the minutest details, this volume admirably fulfills its commendable purpose.

Suction Gas. By Oswald Haenssgen. Pages 86. Cloth, 5 by 7 inches. Published by the Gas Engine Publishing Co., Cincinnati, Ohio.

OWING to the widespread attention which gas engines are attracting among engineers, the appearance of this little work on suction gas may be considered timely. The suction gas producer has been developed and improved in Europe rather than in America, owing to the less abundant supply of coal and other fuels, which has made the subject of fuel economy an important one abroad. In this new type of gas producer, the troublesome boiler and bulky gas holder of other gas generators have been entirely omitted, and the combustible gas is produced directly and exclusively by the suction of the motor. The book gives a detailed description and illustrations of this producer, and also contains chapters on the properties and composition of suction gas, tests of gas engines under European conditions, relative value of various kinds of fuels for producing gas, and also prices and weights of installations of this character. The subject is one that will

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(LITERATURE Continued)

appeal to the up-to-date engineer, and the information contained in the book is important.

MAGAZINES

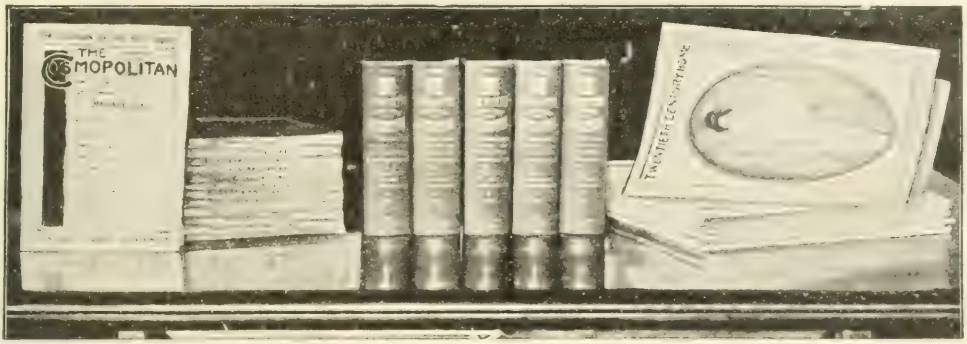
Power (February)—New York

THOSE interested in the steam turbine will find this number of especial value. "Power Required for Condensing Auxiliaries in a Steam Turbine Plant," by J. R. Bibbins, gives complete data, method of obtaining same, and results of a test on the condensing auxiliaries of a 400-K. W. Westinghouse-Parsons turbine. The results, which are plotted for various loads, show the gross power input of the auxiliaries to be 2½ per cent of the total power generated at full load, 3 per cent at half-load, and 4 per cent at quarter-load. It is also pointed out that the power required for the condensing apparatus is dependent principally upon the quantity of water pumped.

Drawings of assembled parts and complete details of a 12-H. P. 24-inch turbine, are shown in an article on Making a Small Curtis Turbine, by H. J. Travis. In addition, eleven performance curves of water consumption under various pressures and speeds, horse-power developed, starting torque, etc., are plotted to a large scale. The turbine comprises about 38 pieces, and weighs 175 pounds. Under ideal conditions 45 H. P. was developed on 35 pounds of steam per horse-power-hour. The curves show clearly how the steam consumption increases with a reduction in either pressure, load, or speed.

"The Kerr Compound Steam Turbine," is a short illustrated description of the latest type of turbine. It is of the tangential class, while the buckets are of the Pelton type.

Under the title "Combustion," C. C. Major discusses in detail the theory and results of combustion. The first part of the article deals with elements, compounds, chemical combinations, etc., special attention being given to oxygen, nitrogen, carbon, hydrogen, and sulphur.



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LITERATURE—(Continued)

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Other articles are: "A Piston Failure in a Large Engine," and "Consulting Engineers and Engine Specifications."

The Rambler Magazine (December)—Kenosha Wisconsin

THE most important article in this number is "Rambler 1905 Productions," by Hugh Dolner. It is particularly interesting to one who runs an automobile, or who is engaged in the automobile industry. In this article the entire construction of the Rambler type of machine is carefully treated. Such details as the automatic spark timer, steering gear, and brake are explained clearly and concisely. The article is well illustrated with cuts showing all parts of the working mechanism, and the complete motor car.

"Non-Freezing Liquid for Cooling the Auto-Car" is a valuable contribution on an interesting problem.

A number of articles on Automobile Meets in different parts of the country, and several on Automobile Trips, are well written and illustrated, especially one by A. T. Keeley, "In the St. Louis Endurance Run." Short readable articles comprise the remainder of this excellent number.

Electrical World and Engineer (January 28)—New York.

"DISTRICT Electric Power Distribution" treats of the system of the South Wales Electric Power Distribution Company, which has recently begun operation in England. The major part of the load consists of power, only one town being supplied with electrical energy for lighting purposes. Power is supplied to different points of the system to the extent of 9,000 horse-power.

A Working Diagram of the Alternating-Current Synchronous Motor, by A. E. Kennelly, shows a graphical method

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LITERATURE—(Continued)

of representing the relations between the E. M. F., current, and power in a single-phase synchronous motor circuit.

A very interesting announcement is made in regard to a new type of incandescent lamp which is said to have an efficiency much higher than that of the carbon filament lamp. The nature of the material used was for some time a secret, but it has now become known that this material is tantalum. This discovery is due to researches made by Messrs. Siemens & Halske. The shape taken by the filament is an innovation, as well as the material.

Other articles include Central Station Distribution; Single-Phase Alternating-Current Distribution; and Developments in Electrical Traction.

American Electrician (January)—New York

AN article entitled "Typical American Hydraulic and Transmission Plant," by C. W. Whitney, takes up the subject of the American River Electric Company's system, which has recently been completed and placed in successful operation in Central California. This is a hydro-electric power and transmission system, being typical of the best water-power plants on the Pacific Coast. The construction is of a particularly high grade and fully described in this article. A large number of photographic views along the system are also shown.

An article by Laurence B. Mather, entitled "American Water Wheel and Water-Wheel Governors," takes up these subjects from the standpoint that there are two general types of water wheels in use in America—one the turbine, and the other the impulse or impact wheel. Numerous cuts are shown of complete water wheels and details of parts. This is a particularly exhaustive article on this subject, and is well worthy of study by anyone interested in this important subject.

"Design and Construction of Small Dynamos and Motors" is one of a series of articles by Cecil Poole on the subject, and, as the title indicates, takes up the design of small dynamo-electric machinery.

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The North Electric Company, Cleveland, Ohio.
Bulletins Nos. 29 and 30. Paper, 8 by 10 inches.

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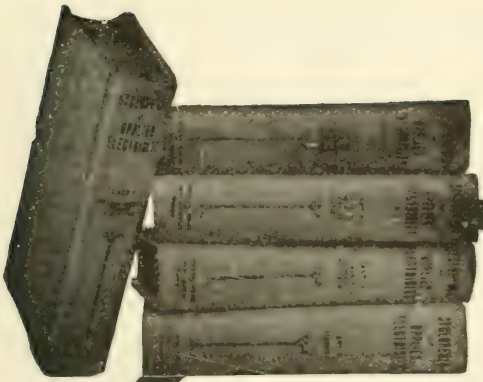

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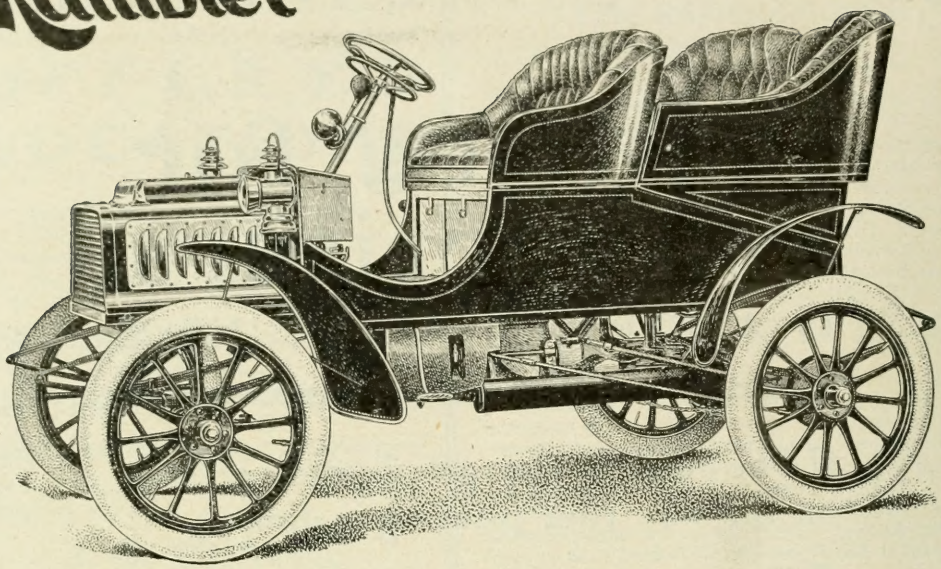

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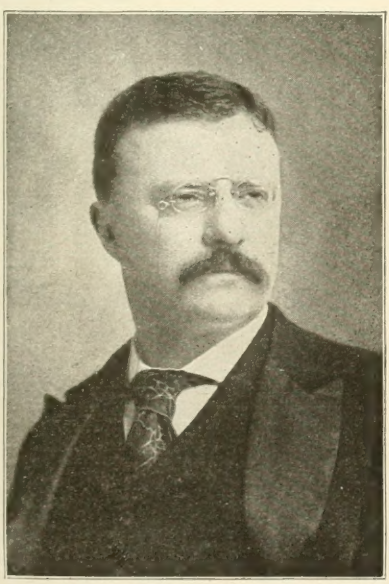

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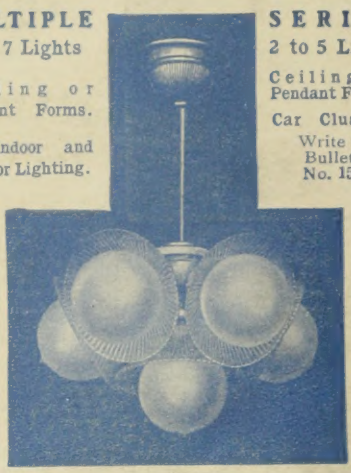

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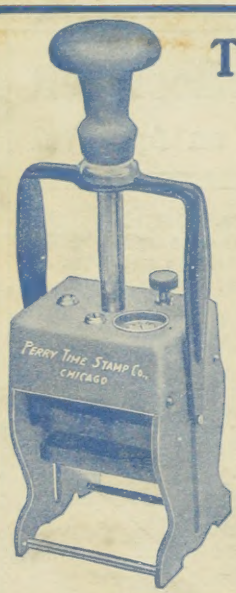

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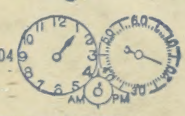

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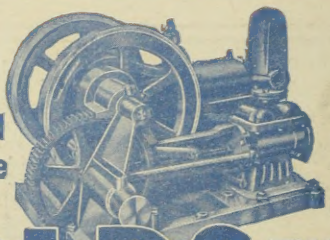

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